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ASTRONAUTICS.—*The exploration of space.*[1]

HUGH L. DRYDEN, National Aeronautics and Space Administration.

(Received May 29, 1959)

The surging tide of technological development has brought us to a new frontier, the frontier of space exploration and travel. We are at approximately the same stage in the development of space vehicles as the Wright Brothers were in the development of the airplane in 1904. In those days few people were interested in the fragile wood, wire, and cloth vehicles which were the fore-runners of our modern jet transports and military airplanes. In fact, as a nation, we were so uninterested that the Wrights took their invention to Europe. When World War I broke out, we found that we had no airplanes of our own. We were compelled to build copies of airplanes developed by other nations.

Today the situation is different. There is widespread public interest. The competition is evident. Many now have faith in the great potentialities of space exploration to benefit mankind. It is a privilege for me to tell you about the steps that are being taken to insure that the United States will occupy its proper role as a leader in space research, development, and operation for peaceful purposes.

The space age began with the launching of Sputnik I by the U.S.S.R. on October 4, 1957. The United States launched its first satellite, Explorer I, on January 31, 1958. At present ten earth satellites have been launched into orbit successfully. Three space probes penetrated to distances of 63,000 to 71,000 miles from the earth. Two space probes reached a velocity high enough to escape from the earth's gravitational field to enter orbits around the sun as man-made planets. Instrumentation on board these space vehicles provided new information about the environment of nearby space, information which increases our understanding of the earth and its atmosphere; of cosmic rays, other particles and radiations encountered by our earth in its journey through space; in fact, of the physical universe in which we live. From the data already returned to earth from satellites and space probes containing equipment developed by Dr. James A. Van Allen, head of the physics department of the University of Iowa, have come the discovery and description of the Great Radiation Belt. This belt consists of clouds of charged particles whose impact on the satellite produces radiation of high intensity harmful to man and capable of damage to film and other photosensitive apparatus. There are in fact two radiation belts believed to be of different origins. The first has its maximum intensity at a height of about 2,400 miles and is believed to be produced as a result of the impingement of cosmic rays on air molecules. The second, reaching its maximum intensity at about 10,000 miles above the earth is believed to consist of particles from the sun, whose atmosphere now appears to reach to the earth and beyond. In both cases the particles are trapped by the magnetic field of the earth and persist for a long time until as they travel back and forth in spiral paths from pole to pole they collide with air molecules releasing some of their energy to form the imposing auroral lights of the far north and south.

[1] Address delivered before the Cosmos Club of Washington on April 13, 1959, and substance of a lecture delivered at the 442d meeting of the Washington Academy of Sciences on May 21, 1959.

In addition to this fascinating discovery which I am not competent to describe in detail, the four U.S.S.R. and eleven U.S. space vehicles so far launched successfully have produced exploratory data on the distribution of matter and magnetic fields encountered in space, as well as data on solar radiation, electric field, photons, heavy nuclei, positive ions, and the physiological reactions of a dog which are as yet reported only in part by U.S.S.R. scientists. Truly an imposing record for the first year and a half of the space age.

In the early months there was wide public discussion of the organization of U.S. activities in space research, development, and operation. As an interim measure cognizance over all space programs was assigned to the Department of Defense and a study of U.S. requirements in space science and technology was undertaken by the President's Science Advisory Committee under the leadership of Dr. James R. Killian. As a result of this study the President on April 2, 1958, recommended to the Congress the formation of a civilian agency to be responsible for space activities concerned with problems of civil space flight, space science, and space technology. Military programs associated with military weapons systems and military operations were continued as the responsibility of the Department of Defense. The President further recommended that the new agency be based on the existing National Advisory Committee for Aeronautics. The responsibilities of NACA in aeronautical research and services in support of military aeronautics and missiles programs were to be continued by the new agency and extended to military space programs. The functions of the new agency were to be considerably expanded over those of NACA to include the development and operation for research purposes of space vehicles.

After extensive hearings and consideration by the Congress the National Aeronautics and Space Act of 1958 became law on July 29, 1958, with most of the features recommended by the President. This Act expresses an important national policy with respect to activities in space, and the National Aeronautics and Space Administration was established to implement this policy. Section 102(a) reads as follows: "The Congress hereby declares that it is the policy of the United States that activities in space should be devoted to peaceful purposes for the benefit of all mankind." In Section 102(c) the Act states the objectives of the aeronautical and space activities of the United States under this policy. In paraphrased form they are:

1. The expansion of human knowledge of atmospheric and space science;
2. The improvement of aeronautical and space vehicles;
3. The development and operation of space vehicles;
4. The study of the potential benefits to be gained for mankind through space activities;
5. The preservation of the role of the United States as a leader in aeronautical and space science and technology and in application thereof to peaceful activities;
6. The interchange of information between civilian and national defense agencies;
7. Cooperation with other nations in aeronautical and space activities and in peaceful application of the results; and
8. The most effective utilization of the scientific and engineering resources of the United States in achieving these goals.

The Act, in addition to the formulation of the policy and these objectives and the establishment of NASA, created an Aeronautical and Space Council to advise the President on all significant aeronautical and space activities and on the assignment of responsibility for specific projects. A Civilian-Military Liaison Committee was also established as a channel for advice and consultation between NASA and the Department of Defense.

On August 8 the President appointed Dr. T. Keith Glennan, president-on-leave of Case Institute of Technology, as NASA's first administrator, and myself as deputy administrator. NASA began operations on October 1, 1958, at which time it absorbed the personnel and facilities of the National Advisory Committee for Aeronautics, thus ending the 43-year existence of NACA by metamorphosis. NASA thus began with nearly 8,000 scientists and engineers, and technical and administrative personnel and five field laboratories: Langley Research Center at Langley Field, Va.; Ames Research Center, Moffett Field, Calif.; Lewis Research Center, Cleveland, Ohio; Wallops Island Station, Wallops Island, Va.; and the High

Speed Flight Station, Edwards, Calif. To carry the new responsibilities there was added to the organizational structure space flight development in addition to aeronautical and space research and business administration. The new responsibilities for development and operation of space vehicles will be carried largely by contract with existing industry and educational groups.

On October 1, as a result of prior review, the President transferred to NASA from the Department of Defense the original U.S. scientific earth satellite project, Project Vanguard, with more than 160 scientists and technologists of the Naval Research Laboratory; five space probes and three satellite projects which were under the direction of the Advanced Research Projects Agency of the Department of Defense, and a number of engine development programs from the Air Force and ARPA. On December 3 the President transferred the functions and facilities of the Jet Propulsion Laboratory, Pasadena, Calif., from the Department of the Army to NASA. At the same time NASA entered into an agreement with the Army whereby the Army Ballistic Missile Agency, Huntsville, Ala., will carry out certain NASA projects.

In the seven months of NASA's existence we have been working with a high sense of urgency on a fourfold task, (1) carrying out the on-going satellite and space-probe projects transferred to the new agency; (2) planning and initiating new projects; (3) establishing long-range plans and objectives; and (4) building an organization adequate to carry out the over-all program. In our remaining discussion together I wish to outline our over-all plans and objectives.

In our present appearances before Congressional committees we are asked to solemnly swear that our testimony will be the truth, the whole truth, and nothing but the truth. Dr. Homer Newell, NASA assistant director for space sciences, after taking this oath, remarked that we do not always know the truth in science and we can only try to tell the truth as we see it today. Space science and technology represents a new and unknown area of knowledge, and no person can now foresee the aeronautical and space activities of the future any more than the Wrights could foresee the aeronautical activities of today in 1903. As you recall, Wilbur stated that "it is not necessary to look too far into the future; we see enough already to be certain that it will be magnificent."

In line with U.S. policy as expressed in the Act, NASA has established objectives which carry out the application of space science and technology to peaceful purposes. Some of the most important relate to the applications of earth satellites to meteorology, communications, navigation, and geodetics. In some of these fields we expect that, after a period of subsidized development, the earth satellite techniques will prove less costly yet more effective than presently available methods.

The objective of NASA's meteorological satellite program is to provide the knowledge, experimental data, and component development required for an operational satellite system for weather observation, analysis, and forecasting. To accomplish this objective requires research and development on vehicles, instrumentation, data-handling techniques, and satellite flights. The increased knowledge obtainable by such a system may well lead to the possibility of doing something about the weather as well as observe and experience it.

The first meteorological satellite, a very primitive one, was Vanguard II, successfully launched on February 17, 1959. It carried two infrared photocells to scan the earth's cloud cover. The instrumentation worked well, and excellent electronic signals were received and recorded on the ground throughout the life of the satellite's batteries. However, the satellite acquired a complex wobbling motion which has greatly complicated the reduction of the data. This satellite was the first toddling step toward our final objective. A second more sophisticated satellite is under construction and later versions are in the planning stage.

Our present concept of the system which is our objective comprises six satellites in polar orbits at altitudes of 500 to 1,000 miles and three satellites in 22,000 mile equatorial orbits which travel at the same speed as the earth's surface and so remain over fixed points on the earth's surface. The satellites will be provided with instrumentation to

observe cloud formations, hurricanes, tornadoes, thunderstorms, temperatures at various levels (inferred from spectral distribution of radiated energy), incoming and reflected solar radiation, etc. The data received from the satellites will be transmitted quickly (perhaps by communication satellites described below) to a central weather computing center, an enlarged version of that operated now by the U.S. Weather Bureau at Suitland, Md., near Washington, which is now engaged in numerical weather prediction. The operational system will be operated by the Weather Bureau, perhaps with NASA assistance in the satellite launchings.

A second NASA objective for the peaceful application of satellites is the development of the knowledge, experimental data, and component development required for a world-wide communication system capable of transmitting wide band messages including television pictures. The accomplishment of this objective requires development of vehicles, transmitters, antennas, receivers, and experimental data on operating equipment. The final system might be operated by an industrial group or by government monopoly as later determined by Congressional policy. One type of system, the passive system described below, permits use of the satellite component by any nation or person providing the necessary ground equipment.

NASA's first experiments are devoted to the development of components of the passive system. It is well known that the moon may be used as a reflector of radio and radar signals if very powerful transmitters and sensitive receivers are used on the ground and the geometrical relations are correct. Satellites provide smaller moons nearer the earth which require less transmitter power and less expensive equipment. According to a study by Dr. John Pierce of the Bell Telephone Laboratories a passive satellite system may prove economically competitive with ocean cable for transatlantic communication. Television transmission would be possible over this system.

The first passive satellite for experiments on this method of communication is scheduled by NASA during this year. Its launching has been delayed by lack of an adequate launching vehicle. The passive satellite consists of a large inflatable sphere 100 feet in diameter which is made of aluminized mylar plastic. The sphere weighs less than 100 pounds and will be placed in a 700- to 1,000-mile orbit. It can be packed for launching is a sphere only two feet in diameter. The satellite should be readily visible with about the brightness of Venus. In use a strong radio signal is reflected from the satellite in all directions, reaching the earth as a weaker signal which can be received by a highly sensitive receiving antenna pointing toward the satellite.

Our present concept of a passive satellite communications system involves 10 to 20 such satellites in orbits at about 3,000-mile altitude. Any nation could use the satellites as reflectors without interference with use by any other nation. Thus the launching of passive communications satellites would be an important contribution to the peaceful uses of satellites by all nations.

Time will not permit discussion of other plans and objectives for practical applications of satellites to problems of trade and commerce. I turn now briefly to the uses of satellites and space probes for the advancement of scientific knowledge of the space environment. The NASA space science program has its roots in the sounding rocket program for exploration of the upper atmosphere which began some 12 years ago with the use of captured V-2 rockets and the subsequent development of special sounding rockets. During the International Geophysical Year this program received great impetus, and the U.S. fired about 200 sounding rockets and launched its first satellites and space probes.

With the cooperation of the Space Science Board of the National Academy of Sciences–National Research Council and the National Science Foundation, NASA has formulated long-range objectives in the space science program and established a definitive program for the next few years. The term "space science" has been coined to denote scientific investigations carried out in space through the use of satellites, space probes, and other space vehicles. It is not a scientific discipline in itself. Though emphasis at present is on the physical sciences, it is clear that bio-

logical science investigations will also be included.

Our program includes a number of areas and their relations one with the other. One area is that of study of the atmospheres of the earth, sun, moon, and planets with respect to chemical composition, density, motions, diffusive processes, absorption of solar radiation, etc. A second area is that of study of the ionospheres. For the earth this region is that from say 50 to a few hundred miles. The presence of the ionosphere permits reflection of radio waves for communication beyond the horizon. The state of the ionosphere is as important to long-range radio communication as is the state of the weather in the lower atmosphere to transportation and other human activities.

A third area of study has already been mentioned, the cosmic rays in interplanetary space, the Great Radiation Belt of Van Allen, and the auroral particles.

A fourth covers the fascinating subjects of magnetism, electricity, and gravity.

A fifth is that of astronomy. Satellite observations place the observer of the sky above the distortion effects of the earth's atmosphere and its absorption of a large part of the radio waves, gamma rays, ultraviolet rays, X-rays, and visible light. As one scientist remarked, satellites permit observation of the universe in full color compared to his present black-and-white picture. Thus in the field of astronomy we are planning to establish and operate unmanned astronomical observatories orbiting above the absorbing atmosphere of the earth and to measure with precision the emission and absorption features of the sun, stars and nebulae in the unexplored ultraviolet, infrared, and X-ray regions of the electromagnetic spectrum.

The nearest object to us in space is the moon. NASA's plans and objectives include unmanned lunar exploration as a preliminary to ultimate manned exploration, and to investigate the surface and interior of the moon and the nearby space, including atmosphere and ionosphere if the moon exhibits such features. The space vehicles used will include lunar probes, lunar orbiters, and vehicles for rough landings, and soft landings of instruments. These vehicles are listed in accord with the estimated order of availability of the necessary vehicles and guidance systems.

The next nearest neighbors of the earth are the planets Venus and Mars. NASA's plans include exploratory probes of the space near these planets as our capabilities permit. At present our payload capacities are so small that only very limited data are obtainable even if the mission is otherwise successful. But as will be described now steps are under way to remedy this situation.

In order to accomplish the long-range objectives outlined and others to be described it is essential that we develop rocket boosters and vehicles capable of putting much larger payloads into space. This is the one area where our competition is definitely ahead. NASA and the Department of Defense have planned a program extending over the next 10 years to provide the vehicles required for foreseen military and nonmilitary space missions. Time permits only a brief sketch of these developments.

At present, except for Vanguard, we are using assemblies of components and vehicles that were designed for other purposes to launch satellites and space probes. They are inefficient and expensive. Improved vehicles will soon be available such as the Discoverer satellite based on the Thor ballistic missile booster and the Hustler engine originally developed for a ground to air missile. NASA is developing a 4-stage solid-propellant satellite vehicle to carry about 150 pounds into a 300-mile orbit. This vehicle, called the Scout, will be much more economical than existing vehicles and will satisfy many of the needs of our scientific program. It will be very useful in international cooperative programs.

NASA has under development the Vega, a 3-stage vehicle using a modified Convair Atlas as first stage, a second stage incorporating a modified General Electric engine which was used in the Vanguard first stage, and a JPL third stage using storable propellants. The Vega will enable us to put several tons in a 300-mile orbit and to send 1,000 pounds to the neighborhood of the moon.

Later vehicles in the program are the Centaur, Saturn, and Nova. Centaur is similar to Vega except that the second stage uses high-energy propellants, liquid hydrogen

and liquid oxygen. The first stage of Saturn is being developed by the Army Ballistic Missile Agency as a cluster of existing rocket engines giving over one million pounds thrust. Nova will be based on a single chamber rocket of over one million pounds thrust, which is being developed by the Rocketdyne Division of North American under NASA contract.

The Atomic Energy Commission and NASA jointly are developing nuclear rockets for application to space missions as the state of development permits and on the study of nuclear power plants for use in satellites.

Finally, NASA's long-range objectives include the exploration of the solar system by man himself. Enroute to this objective are the milestones of orbital flight of man in the simplest vehicle (Project Mercury, much in the public eye), in advanced maneuverable vehicles, in larger satellites carrying several men, in permanent manned orbiting space laboratories, manned flight to the vicinity of the moon and back, and manned landing on the moon and return. The objective of Project Mercury is to begin the manned exploration of space by developing the technology needed to place a man in orbit about the earth for a short time and recover him safely, and by studying man's physiological and psychological performance. By restricting the altitude to a height well below the Great Radiation Belt, no heavy shielding is required. By planning for only a few orbits before recovery, existing life support systems are adequate.

As you know from the public and technical press, the man will travel in a capsule substituted for the nose cone of an intercontinental ballistic missile. The man is supported in a reclining position on a couch for protection against the accelerations imposed by launching and by reentry into the atmosphere. The capsule is provided with equipment to supply oxygen and remove carbon dioxide, communications and navigation equipment, attitude control jets, heat shield to protect from reentry heating, and a parachute for final landing on water. Reentry is initiated by firing a small rocket to slightly reduce the speed of the capsule in orbit.

The orbiting flight of the first Mercury Astronaut will be preceded by extensive tests and qualifications of the capsule and training of the astronaut extending over the next two years. Ballistic flights over short distances, instrumented ballistic and orbital flights, animal passenger flights, are included in this program of testing and evaluation.

The seven Mercury Astronauts were selected from an original group of 100 military test pilots who met the general qualifications. When 80 percent of the first 69 interviewed volunteered to proceed, the interviews were terminated. The list was then narrowed to 32 who were given extensive physical and psychological tests. The seven astronauts will receive the most intensive course of training ever offered to a party of prospective explorers. Every conceivable characteristic of space flight that can be simulated on the ground or in the air will be made a part of their personal experience. Every detail of the launching, guiding, and tracking procedures will be taught them by ground crews, until they know the operation as we know the working of an office in which we have spent the better part of our professional lives. Only one can be first, but there will be several flights in the program.

All this training of the selected pilots, and all this repeated testing of the rocket and its component parts, are directed toward one end: that the first orbital flight of the Mercury vehicle shall be as nearly routine as human ingenuity and practice can make it. We are determined that the risks to the pilot will be no greater than those experienced during the first flights of a new high-performance airplane.

The Mercury project will be followed by others. In due course a permanent manned satellite will be placed in orbit around the earth, to conduct research, and possibly as a station from which to organize deeper penetrations into space. As we master the required technology we will send an expedition to the moon, and later on to Mars, to Venus, and to more distant reaches of the solar system.

May I recall to your mind the vast extent of the reaches of space as mapped by the astronomers. The most important object in our part of the universe is the sun, source of our heat, our light, and in the last analysis our food supply. In its neighborhood are

nine planets which travel in orbits around the sun and accompany the sun in its motion through space. The earth is number three, at just the right distance for our delicate bodies so that we neither roast nor freeze, at a distance of 93 million miles. Our nearest neighbor, as previously mentioned, is the moon, about 240,000 miles away on the average, moving in an orbit about the earth and accompanying us on our yearly journey around the sun. The nearest planet to us is Venus, 26 million miles, the next Mars, 49 million miles away. The farthest planet, Pluto, is 3,680 million miles from the sun.

To comprehend these tremendous distances let us suppose that we now had spacecraft able to travel at 10 miles per second, approximately the initial velocity required to escape from the solar system or 60 times the speed of a jet transport. It would take us 6 hours 40 minutes to travel the average distance to the moon, 24 days to Venus, 58 days to Mars, 108 days to the sun, 11-½ years to Pluto.

The nearest star is 25 million million miles away, and travel to it at 10 miles per second would require 80,000 years. It is evident that our exploration will be confined to the solar system for some time.

The greatest speed we know is that of light, 186,000 miles per second. We call the distance light travels in one year, a light year; it is nearly 6 million million miles. Thus the nearest star is a little over 4 light years away. Our sun is 26,000 light years from the center of our galaxy, the Milky Way. Such distances become almost beyond our comprehension.

Is then the travel of man to the stars a futile dream? You remember the verse:

> The world will last when gone are we
> Without a trace of thee or me.
> Before we came there was no void,
> And when we're gone the same 'twill be.

I wonder. Since the invention of writing the thoughts, the knowledge, and the influence of men who lived thousands of years ago are still available. Each age builds on the shoulders of the past. Who then dares to limit the horizons of the physical universe to be ultimately explored by man? The exploration of space has begun; who knows where it will end?

TRACKING CAMERA PHOTOGRAPHS VANGUARD I IN ORBIT

The Smithsonian Optical Tracking Station at Woomera, Australia, has successfully photographed the Vanguard I earth satellite at the apogee of its orbit, nearly 2,500 miles from the earth. The Woomera station is operated for the National Aeronautics and Space Administration as a part of the civilian space agency's worldwide network of tracking stations. The Baker-Nunn precision satellite tracking camera, manned by personnel of the Woomera Missile Range, took pictures of Vanguard I on three occasions, May 1, 3, and 4, 1959. No other object as small as this 6-inch sphere has been photographed from such a distance. It is comparable to aiming a camera at a golf ball 600 miles away.

The tracking camera, one of 12 located around the world, was especially designed for tracking earth satellites during the International Geophysical Year. The Woomera station is operated under the technical direction of the Smithsonian Astrophysical Observatory for the NASA. Equipment at the station is furnished by the United States; staff and buildings are supplied by the Australian Government.

In a congratulatory note to the staff at the station, Dr. Hugh L. Dryden, NASA's deputy administrator, said the tracking team's efforts demonstrated the true capabilities of the Baker-Nunn camera, thus paving the way for more accurate optical satellite tracking data, essential to precise orbital calculations.

The Vanguard I, developed by the U. S. Naval Research Laboratory for the IGY, was launched on March 17, 1958. It was the second scientific satellite launched by the United States. With a perigee of 402 miles, the satellite is currently making 76 orbits a week. During the week of May 17, it completed 4,590 revolutions around the earth since it was launched. The Vanguard program was transferred from the Naval Research Laboratory to the NASA on October 1, 1958.

The other 11 camera stations are located at: Organ, N. Mex.; Olifantsfontein, South Africa; Cadiz, Spain; Tokyo, Japan; Naini Tal, India; Arequipa, Peru; Shiraz, Iran; Curaçao, N.W.I.: Hobe Sound, Fla.; Villa Dolores, Argentina; and Haleakala, Maui, Hawaii.

GEOLOGY.—*Sulphide mineralization and associated structure in northern Union County, Illinois.* GEORGE A. DESBOROUGH, Southern Illinois University, Carbondale, Ill. (Communicated by David Nicol.)

(Received April 20, 1959)

Minor amounts of sulphide mineralization in Union County of southwestern Illinois have been known for many years, but no attempt has been made to study this outlying occurrence in detail. The area lies midway between the Illinois-Kentucky fluorspar district and the southeastern Missouri lead district and exhibits some characteristics of both. The occurrence is in the complex fault-zone along the Rattlesnake Ferry (Ste. Genevieve) fault and appears as disseminated deposits and as vein filling of fractures in the Backbone limestone of Devonian age. The mineralization consists of galena and sphalerite with subordinate chalcopyrite plus their associated alteration products. The occurrence has characteristics normally attributed to deposits regarded as being of epithermal origin. All features indicate marked structural and stratigraphic control. Subordinate faults with small displacement along the major fault zone seem most favorable for mineralization. Although no systematic prospecting or exploration has been conducted in the area, structural and stratigraphic relationships are favorable for sulphide mineralization.

Since the early 1900's several small-scale operations have been unsuccessfully attemped to extract lead ore from mineralized zones along faults in northern Union County, Ill. These mineralized locales occur along the Rattlesnake Ferry (Ste. Genevieve) fault zone in the S. ½ of sec. 1, T. 11 S., R.3 W. (Alto Pass quadrangle), about 5 miles east of the Mississippi River in the Shawnee Hill Section of southwestern Illinois (Fig. 1).

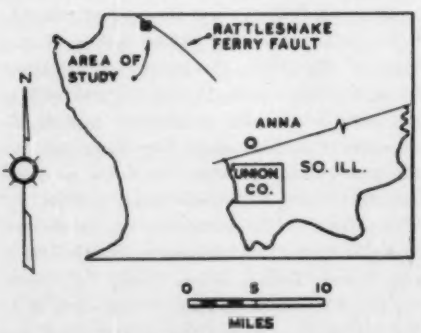

FIG. 1—Index map of area

The area is complexly faulted and, according to Weller and Ekblaw (1940, p. 25), displacement along the Rattlesnake Ferry fault may exceed 1,500 feet. In some areas the numerous faults occur in a zone one-half mile wide; however, in the vicinity of Grassy Knob (just east of the Big Muddy River and south of Rattlesnake Ferry) the zone is only a few yards wide.

On the south side of the major fault zone, the strata are almost exclusively Lower and Middle Devonian. The strata exposed on the north side of the fault are dominantly of Chesteran age (late Mississippian), although many of the hills are capped by Caseyville (Lower Pennsylvanian) outliers.

In the area immediately north of the major fault zone and west of Alto Pass, numerous north-south trending faults complicate the structural and stratigraphic relationships (Ekblaw, 1925; Desborough, 1957). At least two periods of faulting are evident in this area, one prior to Pennsylvanian deposition, and the other during post-Pennsylvanian time (St. Clair, 1917; Ekblaw, 1925; J. M. Weller and Ekblaw, 1940; Weller, 1940; Desborough, 1957).

STRATIGRAPHY

The mineralization and associated structures are apparently restricted to the Backbone limestone and the Clear Creek chert, both of Devonian age. About one-half mile north of the mineralized area Mississippian rocks of Meramecian and Chesteran age are exposed. The complete Chester series is exposed, as well as the Ste. Genevieve formation of the Meramec group. The Chester

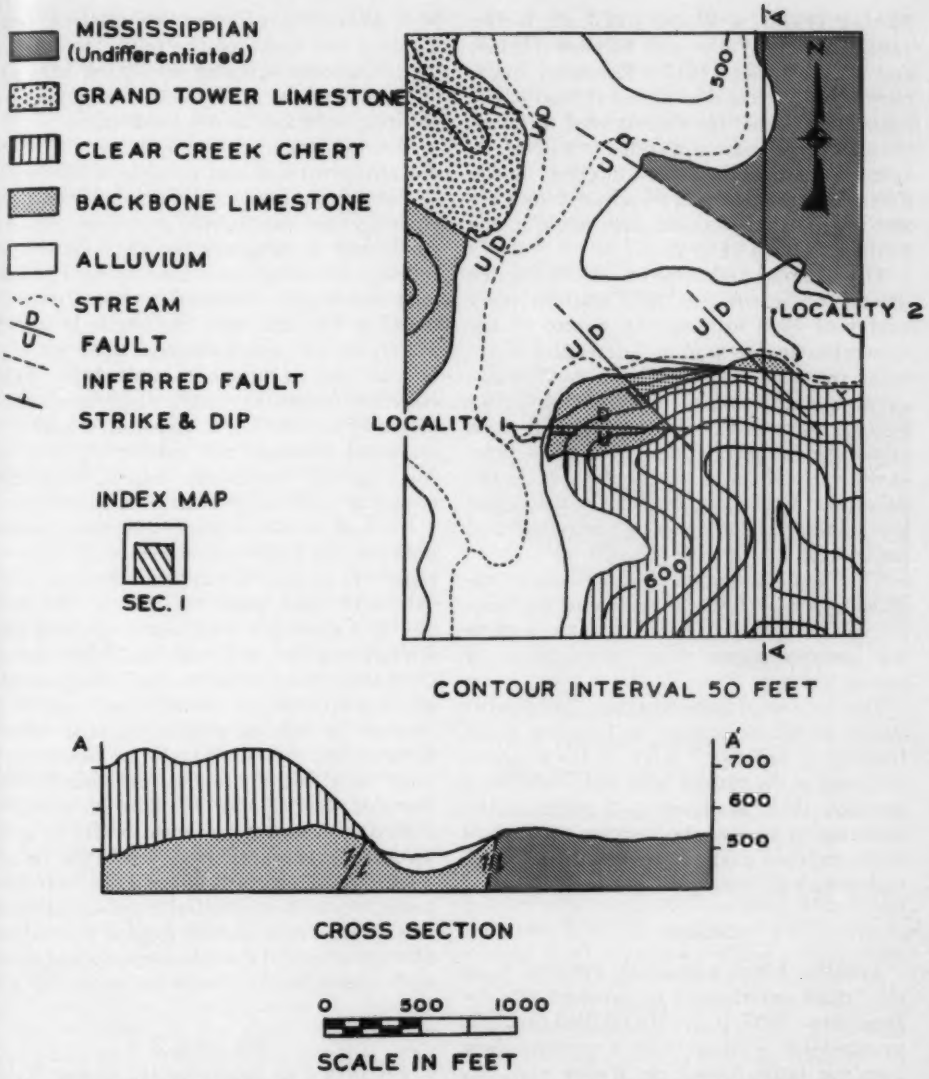

FIG. 2.—Areal geologic map and cross-section of area in Sec. 1, T. 11S., R. 3W., Alto Pass quadrangle, Illinois.

strata are overlain unconformably by Lower Pennsylvanian clastic sediments. The stratigraphic relationships of the Backbone limestone and the Clear Creek chert are as follows:

Middle Devonian
Dutch Creek sandstone (not exposed)
Clear Creek chert.....300 feet thick
Lower Devonian
Backbone limestone.....200 feet thick
Grassy Knob chert (not exposed)

PAST AND PRESENT STUDIES

The general geology of this area has been studied by Worthen (1868), St. Clair (1917), Savage (1920), Poor (1923), Basset (1925),

Ekblaw (1925), S. Weller and J. M. Weller (1939), J. M. Weller and Ekblaw (1940), and J. M. Weller (1945). Recently, Bradbury (1957) wrote a brief description of the mineralized area. He summarized the data obtained in the past and added new observations. Subsequently, local interest in the mineralization has been stimulated. As a result several prospect pits were made in the bedrock of sec. 1 (Fig. 2).

The blasting and removal of overburden during the late fall of 1957 and the early winter of 1958 exposed the nature of the mineralization as well as interesting structural relations. During the period of excavating and blasting, the writer frequently visited, examined, and photographed some of the significant geologic features, several of which have been obscured by later excavations. Thin sections of the wallrock and the mineralized rock were prepared and studied.

This paper attempts to describe and explain in some detail the nature of the mineralization and structure. In some aspects my interpretations differ from those of earlier writings.

Two locales of mineralization will be discussed herein, designated as Locality 1 and Locality 2. Locality 1 refers to the mineralized area at the normal fault near the stream junction (Fig. 2). Locality 2 refers to the mineralized area at the junction of the two faults exposed near the stream in the south valley wall of Hutchins Creek (Fig. 2).

LOCALITY 1

Locality 1 was apparently referred to as the "third caved shaft or prospect pit" by Bradbury (1957, p. 2). He implied that this prospect pit is situated on a northwesterly trending fault, based on Weller and Ekblaw's geologic map (1940, pl. 1). Recent excavations have revealed the mineralization to be along an approximately vertical E-W striking fault which involves only the Backbone limestone at the surface. The displacement is probably small. The brecciation and drag features of the northern fault block indicate it is downthrown.

The host, Backbone limestone, is a light gray, dense limestone, part of which has been altered to ocherous material. A few hundred feet north of the fault, the Backbone limestone contains inch-thick beds of chert. Alteration of the host rock by mineralizing solutions is not evident.

Mineralization is concentrated in the downthrown block and consists of vein calcite and subordinate galena, sphalerite, and chalcopyrite. Smithsonite and limonite occur locally as oxidation products. Galena is found in the calcite as masses up to 6 inches long and as small euhedral crystals disseminated in the limestone. Sphalerite is found as crystalline encrustations upon calcite crystals and as linings in small vugs. Chalcopyrite occurs as small disphenoids enclosed by calcite. The smithsonite is sparsely scattered between the calcite crystals in small, green, crystalline masses. Limonite occurs as pseudomorphs after chalcopyrite.

Contact relations between mineral grains indicate the following sequence of deposition: (1) calcite I, (2) chalcopyrite, (3a) calcite II, (3b) sphalerite-galena, (3c) calcite II. Calcite I is very coarse-grained and semitransparent, and it contains disphenoids of chalcopyrite. Because small disphenoids of chalcopyrite are found upon calcite I crystals in vugs, as well as included within large calcite crystals, deposition of calcite I must have begun prior to and ended after the chalcopyrite stage. Calcite II is represented by a medium-grained, white to gray variety; its contact relations with galena indicate the calcite is younger. However, subhedral crystals of sphalerite are found upon calcite II. These factors suggest the calcite II stage preceded the sphalerite-galena stage and continued after the cessation of the latter.

LOCALITY 2

Locality 2 is in the center of the W.½, E.½, SE.¼, of sec. 1 (Fig. 2). According to Bradbury's report (1957, p. 2), the exact location of the exposure is uncertain since there are many prospect pits in the vicinity. Possibly it was this exposure that Bradbury referred to as the "first shaft," because mineralization here is apparently restricted to the Backbone limestone. Bradbury probably based his locations upon Weller and Ekblaw's preliminary geologic map (1940, pl.

1), which is generalized because of its small scale.

Excavations at this location within the past year have revealed minor sulphide mineralization in the Backbone limestone and complex structural and stratigraphic relationships.

Structural and stratigraphic relationships. —The fault at Locality 2 which strikes N.45–50°W. is a normal one (Fig. 2, 3). It dips about 80° NE., and the stratigraphic displacement is probably less than 5 feet; however, a vein about 3 feet wide occupies the fracture on the north side of the N.80°W. fault (Fig. 3).

The Clear Creek chert and Backbone limestone lie in normal contact on the south side of the major fault (Fig. 3, 4). This fault strikes about N.80°W. and dips 60°SW. (Fig. 3). About 25 feet of Backbone limestone is exposed above the creek bed (Fig. 2). The exposures of Backbone limestone on each side of the fault are apparently in place, and they are almost identical in thin section and hand specimens. To establish whether or not the limestone beneath the Clear Creek chert was a calcareous component of the lower Clear Creek formation, a thin section of the Clear Creek limestone from the locality described by Weller (1940, p. 24) was studied. Mineralogically, the Clear Creek limestone contains abundant glauconite and is much more siliceous than the Backbone limestone at the mineralized locale. Both chalcedony and euhedral to subhedral quartz grains are abundant in the Clear Creek limestone, whereas the Backbone limestone thin sections are essentially quartz-free. At the mineralized locale the Clear Creek chert is not calcareous and is in beds 2 inches to one foot thick, whereas the Backbone limestone is chert-free and conspicuously styolitic. The latter has also been recrystallized by mineralizing solutions or tectonic stress.

The structural and stratigraphic relationships discussed above show that the fault block on the south must have moved down relative to the opposite block (Fig. 3). This is contrary to what one might expect, as the relative displacement along the major fault zone shows that most fault blocks on the southwest side of northwesterly trending faults are upthrown. Also, the regional displacement along the Rattlesnake Ferry fault zone demonstrates that the north side is downthrown. It is not likely that the fault in question is an antithetic fault since it is not in the downthrown block relative to the major displacement along the large fault zone (de Sitter, 1956, p. 154). It has been pointed out that movement in opposite directions along the same fault plane during two periods of faulting may have occurred a few miles northeast of the area discussed

FIG. 3—Diagrammatic sketch of structural and stratigraphic relationships of the Backbone limestone and Clear Creek chert at Locality 2.

here (Desborough, 1957, p. 201). This writer proposes that the fault is probably due to normal fault movement along a former reverse fault plane.

Weller and Sutton (1940, p. 852) have also suspected movement along faults "at several different times and in several different directions, with complete reversal in some places" several miles to the east in the fluorspar district of southeastern Illinois and western Kentucky. Weller and Ekblaw (1940, p. 26) recognized the existence of high-angle thrust faults in southern Illinois and attributed these to compressional forces.

The following observations collectively suggest at least two movements, in opposite directions, along the N.80°W., 60°SW. fault

plane at Locality 2: (1) Stratigraphic relationships signify the south fault block is downthrown (Fig. 3). (2) The major regional displacement along the northeast side of the Rattlesnake Ferry Fault shows the south side is upthrown. (3) Empirical knowledge of the area indicates nearly all northwesterly trending faults have their north fault block downthrown. (4) Dip of strata adjacent to the fault plane due to drag effect indicates reverse fault movement because the strata dip north whereas the fault plane dips south (Fig. 3). (5) Directional

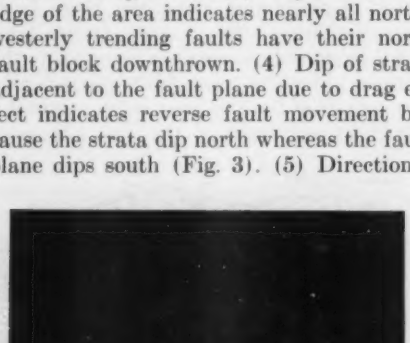

FIG. 4—Slickensides (lower left) developed along N.80°W. fault in Backbone limestone just below Clear Creek-Backbone contact (at pick handle). Locality Two.

smoothness along well-developed slickensides indicates the south fault block to be upthrown (Fig. 4).

The N.45–50°W. fault intersects, continues across, and displaces the N.80°W. fault plane (Fig. 3), indicating the N.45–50°W. fracture occurred later than the last displacement (normal fault movement) along the N.80°W. fault. The N.45–50°W. fault was present before the deposition of the mineralizing solutions which are contained in its fracture. This suggests that the mineralization emplacement may have occurred (a) later than that period of faulting during which the reverse fault occurred and (b) after the normal fault movement along the existing reverse fault plane.

Studies in the Pomona Area a few miles to the northeast have shown that two separate periods of faulting occurred in the area: post-Chesteran–pre-Pennsylvanian and later post-Pennsylvanian displacements along the same fault-plane (Desborough, 1957, p. 201). Evidence suggesting movement along the same fault plane, in opposite directions during separate periods of faulting, has been presented (Desborough, 1957, p. 201).

Weller and Ekblaw (1940, p. 26) imply that thrusting forces originating in the Ozark region resulted in the formation of the Rattlesnake Ferry Fault. The writer agrees. They also suspected this structure "originated in post-Mississippian–pre-Pennsylvanian time and has subsequently been accentuated" (Weller and Ekblaw, 1940, p. 25).

On the assumption that the first displacements along the Rattlesnake Ferry Fault originated during the post-Mississippian interval, reverse-fault movement along the N.80°W. fault at Locality 2 probably occurred at that time. According to Weller's observations (1940, p. 51), local compressional forces would cause reverse fault displacement. The displacement now evident along the N.80°W. fault (Fig. 3) is apparently due to normal-fault movement. This movement suggests tensional forces which were accommodated because a previously formed fault was present.

Mineralization.—The rock at Locality 2 is not appreciably brecciated as it is at Locality 1. Mineralization here consists of vein calcite with minor amounts of galena, sphalerite, and sparsely scattered euhedra of chalcopyrite. Vein calcite occurs abundantly only along the N.45–50°W. fault plane, the mineralized portion of which is not more than 3 feet wide. Galena occurs in chunks up to 6 inches across with well developed cube faces. Replacement is indicated by the random distribution of sphalerite in the Backbone limestone. It is also present as cavity fillings in the form of veinlets an inch in width. The veinlets probably formed along joints, as they are generally parallel to the N.40–50°W. fault. Sphalerite also occurs as cavity fillings along the styolites. It is par-

ticularly conspicuous along both fault planes, including the slickensides in the Backbone limestone (Fig. 4). Galena is present as cavity fillings in the form of veinlets with the same strike as those with sphalerite. They have not been found together in the same veinlet. Some of the veinlets have been oxidized to limonite and exhibit boxworks. Excavations along the N.45–50°W. fault in the creek bed revealed abundant vein calcite and chunks of galena as large as 6 inches in diameter with sphalerite in lesser amounts. No smithsonite was observed here.

The paragenesis at Locality 2 is vague. In one small veinlet contact relations of minerals suggest that some calcite is older than galena. Where sphalerite and calcite are found in veins the sphalerite is older. On the other hand, where sphalerite is randomly distributed in limestone and not in veins, it is younger than the associated calcite. Age relationships between galena and sphalerite are not clear. As at Locality 1, two generations of calcite are inferred if it may be assumed that in usual sequence, sulphides are deposited later than one stage of calcite (McKinstry, 1948, p. 149).

Late in the fall of 1957 an exploration hole 80 feet deep was drilled about 300 feet northeast of Locality 2. It is reported to have penetrated 80 feet of valley fill which consisted mostly of sand and gravel. This suggests that the slope of the hill on the south valley wall may continue downward as much as 100 feet vertically with the same steep gradient now exhibited by the hill above the valley-fill (cross-section, Fig. 2).

CONCLUSIONS

(1) Mineralization is concentrated along both E-W and NW-SE trending faults.

(2) The glauconite content and abundance of silicic (chalcedony and quartz) material in the Clear Creek limestone of this area permits its differentiation from upper Backbone limestone.

(3) Evidence strongly suggests movement along the same fault plane in opposite directions during two separate periods of faulting.

(4) Reverse fault movement along the Rattlesnake Ferry fault zone is suggested.

(5) The upper Backbone limestone may be a host for sulphide mineralization in adjacent areas where it is not siliceous and faults are present.

ACKNOWLEDGMENT

I wish to thank Dr. and Mrs. David Nicol and Dr. Stanley Harris, Jr., for criticism of the manuscript and Dr. Dewey Amos for helpful suggestions during the investigation. I also acknowledge the assistance of K. Dean McIlravy in preparing the illustrations.

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ENTOMOLOGY.—*Seven new galerucid beetles from the West Indies.* DORIS H. BLAKE, Arlington, Va.

(Received April 21, 1959)

Six of the seven new species of Galerucinae from the West Indies described in this paper were collected by Fernando de Zayas in Cuba. He has been collecting insects there for many years until he has a large number which may in time form the nucleus of a National Collection of Cuba.

Monocesta cubensis, n. sp.

Fig. 4

About 6 mm in length, elongate oblong, the elytra covered wth fine pale pubescence, prothorax with a transverse groove, dirty yellowish brown, the head with a piceous band on either side, leaving only a narrow pale vertex; elytra with broad dark humeral vitta having a violet lustre and extending to the apex and uniting with a narrow marginal vitta, a shorter subsutural vitta uniting across the base with the others but not reaching the apex; breast and abdomen except tip dark, legs and antennae bicolored.

Head with a broad piceous band extending on either side from occiput about eye, leaving a narrow pale yellow brown stripe down front; mouthparts deep brown, occiput smooth with a few short hairs at base of head, frontal tubercles distinct. Antennae with only the six basal joints present in the single specimen, these pale at base, piceous at apex, second and third joints subequal, fourth as long as second and third together, fifth shorter than fourth. Prothorax approximately twice as broad as long, almost rectangular with a strong tooth at each angle, a transverse median sulcus and a smaller one in the middle over the occiput; surface shining, impuncate, yellowish brown. Scutellum dark with a violaceous luster, densely pubescent. Elytra elongate, not perceptibly wider apically, humeri prominent, a short intrahumeral sulcus, faint subcostate ridges along the middle, surface shining feebly beneath the very fine and appressed pale pubescence, and densely, finely, and shallowly punctate; pale yellow-brown with a broad subsutural dark vitta having a violaceous luster and not reaching apex, a broad lateral vitta from humerus to apex and a marginal vitta uniting at humerus and apical curve with the lateral vitta. Body beneath with breast and abdomen except the tip dark. Legs having the anterior and middle femora pale with a median and apical dark area, the posterior femora dark at apex, anterior tibiae dark on one side, middle and posterior tibiae dark at base and apex, tarsi with apex of each joint dark. Length 6 mm; width 2.3 mm.

Type, female, in collection of F. de Zayas, from La Breña, Moa, Oriente Province, Cuba, collected by Fernando de Zayas and Pastor Alayo.

Remarks.—One species of *Coelomera* has been described from Cuba by Suffrian, *C. liturata,* and although the description resembles somewhat the present species, the beetle is evidently a true *Coelomera* in that the third antennal joint is twice as long as the second. In addition only two washed-out pale vittae are on the elytra, and the elytra are somewhat widened behind, which is not the case in the present species. This is the first *Monocesta* known from the West Indies. In Clark's classification of the genus it belongs to Division B, the smaller, more parallel-sided beetles, with the elytra not postmedially dilated.

Galerucella melanocephala, n. sp.

Fig. 7

About 5 mm in length, oblong oval, covered with short, pale, closely appressed pubescence, the elytra more densely and coarsely punctate than the prothorax, the prothorax depressed at sides and middle; pale yellow-brown, the head more or less black over occiput, antennae with apices of joints 1 to 7 black, rest dark; femora, tibiae and tarsi dark at apices, elytra with three pale reddish brown vittae on each, becoming indistinct before apex.

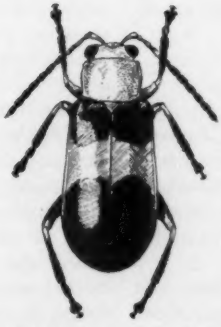
Head with interocular space more than half its width, a median line down occiput to frontal tubercles, upper part of head dull, closely punctate, and covered with pale pubescence; interantennal area flat, upper part of head dull black usually, sometimes dark on either side with a pale area between, from tubercles to labrum pale, labrum dark. Antennae not extending to middle of elytra, stout, the third joint longest, pale with the apices of joints 1 to 7 black,

1. Galerucella spiloptera

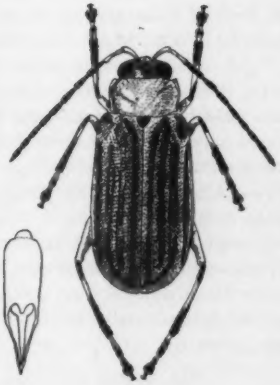
2. Ectmesopus zayasi

3. Ectmesopus nigrolimbatus

4. Monocesta cubensis



5. Leptinotarsa quadrimaculata



6. Chthoneis vittata

7. Galerucella melanocephala

8. Chthoneis vittata ♀?

FIGS. 1–8.—West Indian Galerucinae.

8 to 11 entirely dark. Prothorax twice as wide as long, widely depressed at sides and down the middle, lateral margin somewhat angulate, a small tooth at basal and apical angles; surface punctate, and covered with pale appressed pubescence, entirely pale. Scutellum squarish, pale. Elytra densely and strongly punctate, covered with short pale pubescence, through which on the pale yellow brown surface the punctures are apparent; three rather narrow pale reddish brown vittae on each elytron, becoming indistinct before apex, remnants of another below humerus on the side, not apparent from above. Body beneath pale with the breast and area about coxae a little darker; legs pale, the apices of femora, knee of tibiae and apices of tibiae and tarsi black. Length 5.3 to 5.8 mm; width 2.2 mm.

Type, male, U.S.N.M. type no. 64684, taken at La Breña, Moa, Oriente Province, Cuba, in June 1954 by F. de Zayas and Pastor Alayo. A second specimen was taken at Yunque, Oriente Province, in July 1955 by Zayas, and a third at Piloto, Moa, Oriente Province, June 1954, by Zayas and Alayo.

Remarks.—This is distinguished from the other Cuban species of *Galerucella* by the black or partly black occiput (one specimen from Piloto has the occiput and tubercles black with a pale area between).

Galerucella spiloptera, n. sp.

Fig. 1

About 4 mm in length, oblong oval, covered with fine pale pubescence, punctate beneath, pale yellow brown, the elytra with deep brownish spots and remnants of vittae along suture, middle of elytra and along the sides; antennae pale with apices of joints a little darker.

Head with interocular space more than half its width, a median depressed line down occiput to inconspicuous frontal tubercles, area between antennal sockets flat, lower front short, labrum small, a short, closely appressed pale pubescence covering occipital sculpture. Antennae stout, extending below humeri but not to middle of elytra, third joint longest, all joints pale with apices a little darker. Prothorax approximately twice as wide as long with slightly rounded sides, surface widely depressed on sides and in middle, covered with short, closely appressed pale pubescence hiding the punctation beneath; entirely pale. Scutellum pale. Elytra densely and strongly punctate, the punctures visible through the dense, fine, closely appressed pubescence, a long incurving intrahumeral depression, another along the suture below scutellum, and another along the side before the apex; yellow brown with cinnamon brown spots and fragments of vittae along the suture, a spot near base in middle, another half way down and two elongate ones before apex, a spot covering humerus and extending down the side, more or less interrupted to apical curve. Body beneath a little deeper brown than upper surface, shining, thinly pubescent. Legs entirely pale. Length 4.2 mm; width 1.8 mm.

Type, male, U.S.N.M. type no. 64683, taken in Miami, Fla., from a plane from Curaçao, Dutch West Indies, via Jamaica, B.W.I., collected by W. F. Buren on March 29, 1946.

Remarks.—The spotted markings, or interrupted elytral vittae, differentiate this small species from the others in the West Indies. It somewhat resembles *G. interrupta* Jacoby from South America, a larger, less pubescent species.

Chthoneis vittata, n. sp.

Figs. 6, 8

About 5 mm in length, oblong oval, shiny, densely punctate, the elytra faintly costate, dirty yellow brown, the head and breast deeper brown, antennae, except the basal joints, brown, each elytron with four more or less interrupted brownish vittae, tibiae and tarsi bicolored.

Head with interocular space approximately half width of head, frontal tubercles large and distinct, a large shallow fovea on each side near eye, a short, narrow carina between antennal sockets, lower front short; deep brown in color with the labrum darker brown. Antennae long and slender, the three basal joints pale, rest dark brown, second and third joints together equal fourth in length, rest long but not so long as fourth, and gradually diminishing a little. Prothorax almost twice as wide as long, widest apically with a broad tooth at apical angle, disk a little uneven with a slight bump on either side near margin, surface shiny, finely punctate, entirely yellow-brown. Scutellum dark brown. Elytra rather depressed, several costae more distinct in apical half; surface shiny, densely and somewhat rugosely punctate; yellow brown with four deep reddish brown vittae on each elytron, the second and third being interrupted before apex, and the lateral one broadening to cover humerus. Epipleura vanishing soon after the

middle. Body beneath pale with breast in part deep brown and tibiae at knee and towards apex dark, the tarsal joints pale at base and dark at apex. Coxal cavities open, claws appendiculate. Length 5.2 mm; width 2 mm.

Type, male, U.S.N.M. type no. 64685, from Piloto, Moa, Oriente Province, Cuba, collected in June 1954 by F. de Zayas and Pastor Alayo. One paratype in collection of F. de Zayas.

Remarks.—This third species of *Chthoneis* has been collected by Zayas and Alayo in the mountains of Oriente Province, Cuba. This one differs from the other two West Indian species in being vittate, but is of the same dirty yellowish brown coloration otherwise. The aedeagus bears a strong resemblance to that of *C. insulae* Blake, also from Cuba. A specimen collected at Gran Tierra, Moa, Oriente Province, on June 5, 1951, by Zayas is considerably larger (length 7 mm; width 2.8 mm), and darker in coloring. The prothorax in relation to the elytra is not so wide. Unfortunately only one specimen, a female, is at hand, and it is not clear from this single specimen whether this is a distinct species or merely a large female specimen of *C. vittata*. A drawing has been made of it.

Ectmesopus zayasi, n. sp.

Fig. 2

About 2 mm in length, narrowly oblong, shining, deep blue above except for the wide pale margin on the prothorax and the pale lower part of the face, the legs pale with apices of middle and posterior tibiae and tarsi brownish; lower surface pale, the breast a bit darker. Antennae in male with the two terminal joints enlarged and middle tibiae notched near apex.

Head with interocular space approximately half width of head, upper part piceous with fine punctures, tubercles and lower front pale yellow; tubercles distinct, a narrow carina down lower front. Antennae in male with tenth and eleventh joints enlarged, dark brown, the basal joints a little paler. Prothorax narrow, a little wider than long, with nearly straight sides, without depressions, shining deep piceous with a bluish luster, the margins pale yellow; impunctate. Scutellum dark. Elytra shining deep blue with distinct punctation. Body beneath pale, the breast a little darker, legs pale with the apical half of middle and posterior tibiae and tarsi deeper brown. Middle tibiae in male notched. Length 2 mm; width 0.9 mm.

Type, male, from Somorrostro, San José de las Lajas, Havana Province, Cuba, collected by F. de Zayas, and in his collection.

Remarks.—None of the other species of *Ectmesopus* so far described except *E. tristis* Blake, which is entirely dark, has so nearly dark a pronotum, in this case only the margin on the sides is pale. The usual abnormality of the male antennae is in the last two thickened joints.

Ectmesopus nigrolimbatus, n. sp.

Fig. 3

About 3.5 mm in length, elongate oblong-oval, shining, the elytra densely and distinctly punctate, pale reddish yellow with the eight basal antennal joints darker, the femora with a dark streak above, tibiae and tarsi dark, sides of pronotum narrowly dark, elytra deep blue.

Head with interocular space half width of head, occiput shining and smooth, very finely punctate, frontal tubercles well defined, a narrow carina between antennal sockets running down front. Antennae not reaching the middle of the elytra, third joint a little longer than second, about half as long as fourth; basal eight joints deep brown, apical three reddish yellow. Prothorax nearly as long as wide, with slightly curved sides, disk not depressed but smoothly convex, basal angles oblique; pale reddish yellow with sides narrowly piceous, the dark area wider anteriorly, surface shining, impunctate. Scutellum reddish brown. Elytra slightly wider apically, with distinct intrahumeral sulcus and well marked humeri; shining, densely and distinctly punctate, deep blue. Body beneath reddish yellow, the femora pale with a dark streak above and at apex, front tibiae dark on upper side, pale beneath, middle and hind tibiae entirely dark, tarsi dark. Length 3.7 mm; width 1.7 mm.

Type, female, from Piloto, Moa, Oriente Province, Cuba, collected in June 1954 by Fernando de Zayas and Pastor Alayo, and in the collection of Zayas.

Remarks.—Although only a female of this species is known, I am pretty sure that the male has notched middle tibiae and probably some deformity of the antennal joints. The only two other species having a close resemblance to this are from Haiti and the Dominican Republic, *E. angusticollis* Blake and *E. leonardorum* Blake. Both species have dark sides to the prothorax but differ from the rest of the genus in being more slender.

Leptonesiotes quadrimaculata, n. sp.

Fig. 5

About 5.5 mm in length, elongate oblong oval, the elytra finely and confusedly punctate, pale reddish, the antennae, tibiae and tarsi deeper brown, the femora in basal half with a metallic luster, the abdomen also metallic, the elytra with a large basal fascia interrupted at the suture, and an apical one covering apical half, these spots being bluish green.

Head with interocular space half its width, occiput well rounded, smooth, shining, nearly impunctate; frontal tubercles distinctly marked, a short carina between antennal sockets; head entirely pale reddish. Antennae not extending to the middle of the elytra, gradually thickening toward apex, third joint shorter than fourth, basal joints pale, the remaining ones deeper brown. Prothorax a little wider than long, with nearly straight sides, apical angle obtusely truncate, disk smoothly convex, without depressions, entirely pale reddish, shining, impunctate. Scutellum pale. Elytra wider than prothorax and slightly wider apically, a short intrahumeral sulcus, surface finely punctate, shining, pale reddish with a broad basal fascia narrowly interrupted at the suture of lustrous bluish green, and another even broader area covering apical half of elytra. Body beneath reddish brown with the middle of the breast and abdomen darker brown, the abdomen having a metallic lustre, femora also with metallic lustre, except at apex which is pale; tibiae and tarsi brown. Anterior coxal cavities open. Claws appendiculate. Length 5.7 mm; width 2 mm.

Type, female, collected at Rancho Luna, Cienfuegos, Las Villas Province, Cuba, in June 1955, by Fernando de Zayas, and in his collection.

Remarks.—Although no male has been examined, I believe that this is closely related to *Leptonesiotes cyanospila* (Suffrian) and that the male has notched middle tibiae and possibly enlarged hind femora. It has a color pattern similar to that species but instead of the small basal and apical spots, the present species has spots so large as to form basal and apical fasciae.

AMERICAN INSTITUTE OF CHEMISTS HONOR AWARD

THOMAS R. HENRY, the *Washington Star's* science columnist, was recently presented with the annual honor award of the Washington Chapter, American Institute of Chemists. Mr. Henry was cited for his service to science as a professional writer and author and for his ability and untiring efforts in keeping the public informed of important and noteworthy advances in science through the medium of the press.

The presentation was made by Dr. Emil Ott, past-president of the American Institute of Chemists, at a dinner held at the Army-Navy Club on May 27, 1959. Dr. Ott emphasized Mr. Henry's contributions to science reporting and his efforts in the education of editorial writers on the importance of disseminating science news to the public.

The invitation address was delivered by Benjamin McKelway, editor of the *Evening Star*. He praised Mr. Henry for his ability as a reporter who has written articles on many important news events. He also praised Mr. Henry's style and firm grasp of his subjects.

In his acceptance address, Mr. Henry outlined the progress made in science reporting over the past 30 years. Further, he pointed out that journalism and science have been accepting each other and as a result have contributed to public understanding and progress of science itself.

ZOOLOGY.—*Muscles of the hip and thigh of the emperor penguin.* L. R. SETTY, School of Medicine, Howard University. (Communicated by Herbert Friedmann.)

(Received March 11, 1959)

Some emperor penguins, *Aptenodytes fosteri*, recently brought from the Antarctic to the zoo at Portland, Oreg., died from an epidemic of aspergillosis. After autopsy, some parts of the bodies of the dead birds were in a satisfactory condition for anatomical study. The musculature of the hip and thigh was one of such parts.

METHOD

One specimen was prepared to show the skeleton of the region; another, the musculature. The latter was preserved in a solution made of a mixture of equal parts of 4-percent formaldehyde, glycerine, and 95-percent alcohol. This specimen was used for the dissection of the muscles.

The function of each muscle was determined by pulling on the muscle from near the point of insertion toward the point of origin.

The descriptions of the muscles of the hip and thigh of a penguin, *Eudyptes chrysocome*, by Watson (1883) were used as a guide.

Although Watson in his work on *Eudyptes chryosocome* considered the trunk to be in a horizontal position, the natural vertical position of the trunk is taken as the basis of orientation in the present study.

RESULTS

The bones serving for the attachment of the muscles of the hip and thigh are shown in the accompanying labeled photograph (Fig. 1).

In both the fresh and the preserved conditions, the muscles are very dark red-brown. Their strong fishy odor remains even after the addition of the above preservative.

The superficial muscles of the lateral aspect of the hip and thigh (Fig. 2) are the following:

Sartorius. This is a very large, elongated muscle and the most cephalic of all the muscles of the thigh. It originates by an aponeurosis from about 2.5 cm of the cranial end of the coalesced spinous processes of the lumbosacral portion of the vertebral column and the spinous process of the four thoracic vertebrae immediately above. It arises also along the dorsolateral edge of the cephalic end of the ilium. The fibers pass obliquely to the insertion of the muscle on the anterocephalic part of the patella.

Sartorius flexes the thigh and extends the leg.

Rectus femoris. The cephalic portion of the musculoaponeurotic sheet that covers the lateral surface of the thigh is rectus femoris. It arises by an aponeurosis from the coalesced spinous processes of the lumbosacral portion of the vertebral column. The fibers run transversely to the insertion which is by a tendon in common with the tendon of extensor cruris (Fig. 3) to the posterior side of the patella.

Rectus femoris flexes the thigh and extends the leg.

Tensor fasciae femoris. The caudal portion of the musculoaponeurotic sheet that covers the lateral surface of the thigh is tensor fasciae femoris. It originates from the coalesced spinous processes of the lumbosacral vertebrae by an aponeurosis shared with rectus femoris. The fibers take a transverse course, and the insertion is by a tendon into the posterocaudal part of the patella and the cephalic end of the lateral upper tibial crest (Fig. 1).

This muscle extends the thigh and flexes the leg.

Biceps femoris. This is a large muscle immediately caudad of tensor fasciae femoris. It originates along the posterior border of the innominate bone and on the caudal margin of the tendon of origin of the tensor fasciae femoris. Its fibers run laterally and slightly caudally to the insertion which is made by a tendon on a tubercle on the outer side of the fibula at the junction of the upper and middle thirds of that bone (Fig. 1). The tendon of insertion passes through a loop of a band-like tendon extending from the distal end of the lateral surface of the shaft of the femur to the tendinous outer head of origin of a leg muscle (gastrocnemius). The loop is thickened where it makes a sharp bend around the caudal border of the tendon of biceps femoris.

The sciatic nerve lies just below biceps fem-

oris and runs almost parallel to the long axis of this muscle. As soon as the nerve makes its exit from the pelvis, it sends branches into biceps femoris (Fig. 3).

Biceps femoris is an effective flexor of the leg.

Semitendinosus. Semitendinosus is a large muscle situated immediately caudad of biceps femoris and is essentially as wide as that muscle. Semitendinosus arises from the most posterior part of the caudal processes of the innominate bone. It also arises from the transverse processes of the third, fourth and fifth caudal vertebrae. Most of the fibers pass essentially in the transverse plane. Insertion is by a ribbonlike tendon about 3.75 cm long and 1.25 cm wide into the distal end of the medial upper tibial crest (Fig. 1).

This muscle flexes the leg and extends the thigh. If the knee joint be flexed, the posterior fibers depress the tail.

The deep muscles of the hip and thigh (Fig. 3) are as follows:

Gluteus medius. Gluteus medius is a large muscle. It arises from the whole posterior surface of the ilium and from the lateral surface of some of the coalesced spinous processes of the lumbosacral region. The fibers run caudolaterad and are inserted by a tendon on the greater tro-

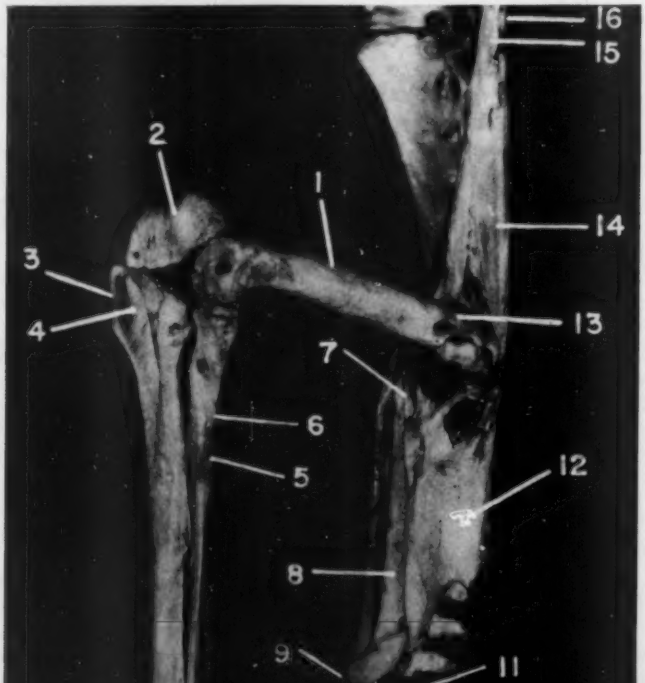


FIG. 1.—Lateral aspect of the portion of the skeleton of *Aptenodytes fosteri* to which muscles of the hip and thigh have attachment. Not all the thoracic vertebrae involved are shown. 1, Shaft of the femur. 2, Groove on the patella for the tendon of musculus ambiens. 3, Medial upper tibial crest. 4, Lateral upper tibial crest. 5, Tubercle of the fibula. 6, Groove on the fibula for the tendon of musculus ambiens. 7, Obturator foramen. 8, Pubic portion of the innominate bone. 9, Cartilaginous tip of the pubic bone. 10, Pygostyle. 11, Transverse process of a caudal vertebra. 12, Ischium portion of the innominate bone. 13, Greater trochanter. 14, Coalesced spinous processes of the lumbosacral portion of the vertebral column. 15, Ilium portion of the innominate bone. 16, Spinous process of a thoracic vertebra.

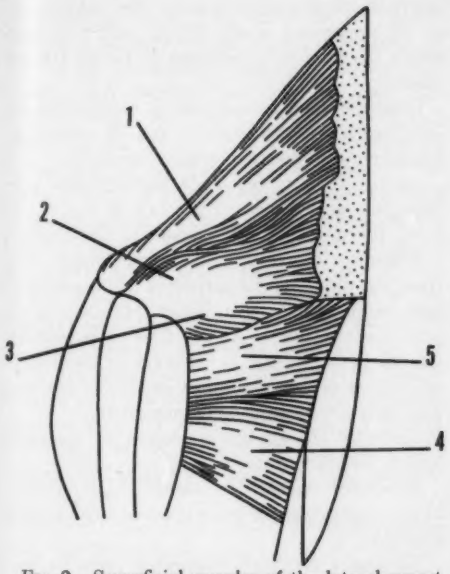


FIG. 2.—Superficial muscles of the lateral aspect of the hip and thigh of *Aptenodytes fosteri*. 1, Sartorius. 2, Rectus femoris. 3, Tensor fasciae femoris. 4, Semitendinosus. 5, Biceps femoris.

chanter of the femur and to a lesser extent on the articular capsule of the hip joint.

The cephalic third of gluteus medius is concealed by sartorius; the caudal two-thirds are covered by the aponeurosis of origin common to rectus femoris and tensor fasciae femoris.

Gluteus medius rotates the hip joint medially.

Gluteus minimus. Gluteus minimus is smaller than gluteus medius. It originates along the lateral border of the ilium and from a tendinous sheet between it and gluteus medius. The fibers run caudolaterad and insert by a tendon on the greater trochanter of the femur anterolaterad of the insertion of gluteus medius.

Much of the posterior surface of gluteus minimus is covered by gluteus medius.

Gluteus minimus rotates the hip joint medially.

A third gluteal muscle has not been recognized in penguins.

Extensor cruris. Extensor cruris is a large muscle mass which originates from the lateral and cephalic surfaces of the shaft of the femur. The part on the cephalic surface is much larger than the part on the lateral surface, and it arises about 2.5 cm more proximally than that on the lateral surface. The cephalic part inserts into the upper truncated extremity of the patella. The lateral part inserts into the tendon of tensor fasciae femoris and hence reaches the lateral surface of the patella and the cephalic end of the lateral upper tibial crest.

Extensor cruris is covered laterally by the musculoaponeurotic sheet formed by rectus femoris and tensor fasciae femoris.

Extensor cruris functions as an important extensor of the leg.

Adductor longus. This muscle arises from about 3 cm of the posterior border of the ischium portion of the innominate bone. The fibers run obliquely to the point of insertion near the distal end of the caudal border of the shaft of the femur.

Adductor longus is crossed laterally by the sciatic nerve. This nerve and adductor longus are concealed by biceps femoris. At its origin, the adductor longus crosses obturator externus;

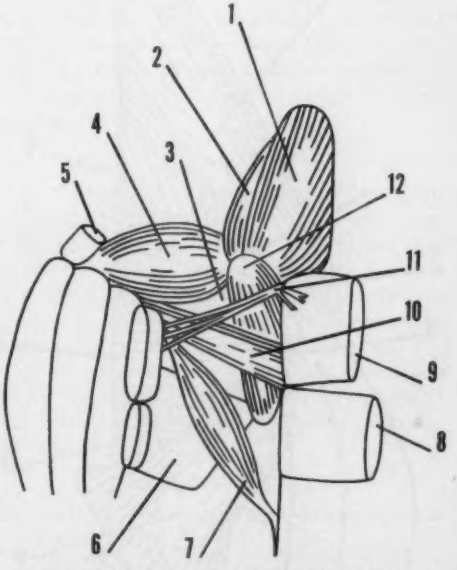


FIG. 3.—Lateral surface of the deep muscles of the hip and thigh of *Aptenodytes fosteri*. Sartorius has been cut off at its insertion. Rectus femoris and tensor fasciae femoris have been entirely removed. Also biceps femoris and semitendinosus have been bisected and their cut ends reflected. 1, Gluteus medius. 2, Gluteus minimus. 3, Adductor magnus. 4, Extensor cruris. 5, Sartorius. 6, Semimembranosus. 7, Crurococcygeus. 8, Semitendinosus. 9, Biceps femoris. 10, Adductor longus. 11, Sciatic nerve. 12, Obturator externus.

at its insertion, it makes contact with adductor magnus. Its tendon of insertion unites with that of crurococcygeus.

The action produced by adductor longus is extension of the thigh.

Crurococcygeus. Crurococcygeus is a long muscle, tapering at each end and measuring over 22.5 cm from the origin to the insertion. It arises by a flat tendon for a distance of 1.25 cm from the cephalolateral border of the pygostyle. The tendon becomes slender and rounded before joining the muscle proper. The muscle fibers take an oblique course; and insert by a long, narrow tendon into the lateral side of the shaft of the femur distad to the tendon of insertion of adductor longus to which it is fused. Just distad to the insertion of crurococcygeus is the attachment of the upper end of the fibrous pulley through which the tendon of insertion of biceps femoris passes.

Crurococcygeus is covered by semitendinosus and biceps femoris laterally and by semimembranosus and adductor magnus medially.

Acting with its fellow of the opposite side, crurococcygeus depresses the tail. If the tail be fixed, the muscle is an extensor of the thigh.

Obturator externus. Obturator externus arises from the whole lateral surface of the innominate bone caudad of the acetabulum, exclusive of the pubic part of this bone. The fibers run cephalolaterad to the tendon of insertion on the greater trochanter of the femur just caudad of the tendon of insertion of gluteus minimus.

Laterally the muscle is crossed by adductor longus and the sciatic nerve.

Obturator externus rotates the thigh laterally. It is an antagonist of gluteus medius and gluteus minimus.

Obturator internus. Obturator internus (not shown in the figure) is an elongated oval muscle. It arises from the greater part of the medial surface of the ischium, the pubis and the membrane between these two bones. The fibers pass cephalad and end on a tendon which passes through the obturator foramen and which is inserted on the greater trochanter of the femur mediad of the insertion of obturator externus.

Since this muscle lies on the inner side of the bony pelvis, only its tendon is in contact with obturator externus.

Obturator internus assists obturator externus in lateral rotation of the thigh.

Gemellus. Gemellus (not shown in the figure) is small and quadrilateral. It arises from the lateral side of the innominate bone close to the margin of the obturator foramen. The muscle is divided into two slips by the tendon of insertion of obturator internus. The fibers run laterad to the insertion on the caudal border of the greater trochanter of the femur just mediad to the tendon of insertion of obturator internus.

The muscle is concealed by the insertion of obturator externus.

Gemellus is a lateral rotator of the thigh.

The superficial muscles of the medial aspect of the hip and thigh (Fig. 4) are the following:

Musculus ambiens. This is a flat, superficial muscle on the medial side of the thigh. It has

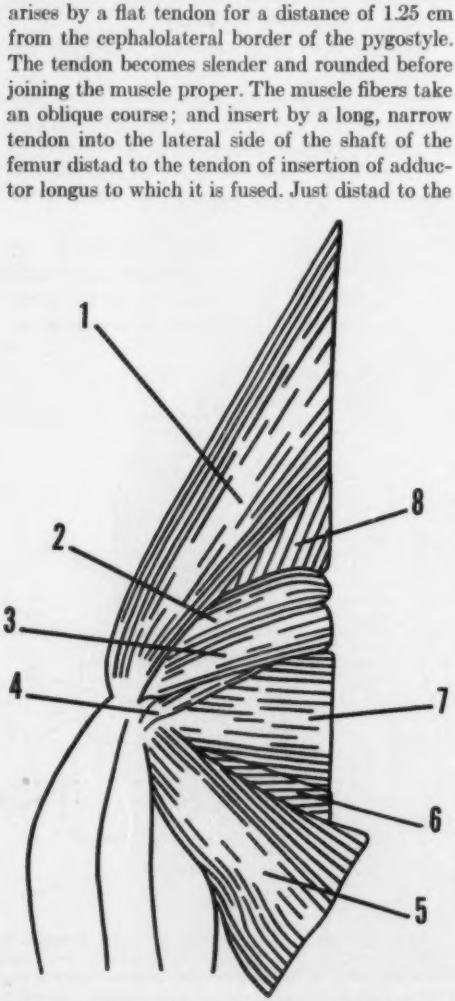


FIG. 4.—Superficial muscles of the medial aspect of the hip and thigh of *Aptenodytes fosteri*. 1, Sartorius. 2, Extensor cruris. 3, Musculus ambiens. 4, Gracilis. 5, Semimembranosus (abdominal head). 6, Semimembranosus (pubic head). 7, Adductor magnus. 8, Gluteus minimus.

an origin of about 3.75 cm from the lateral margin of the cephalic end of the pubic bone. It extends toward the knee and tapers to a tendon which is 0.6 cm wide and 11.25 cm long. This tendon crosses the front of the knee joint in a groove on the patella and in a groove on the lateral side of the proximal one third of the fibula (Fig. 1). Then this tendon passes medially to the tendon of insertion of biceps femoris and joins the head of a leg muscle (flexor perforatus digitorum) which arises from the lateral side of the distal end of the femur. The part of the tendon that passes over the surface of the groove on the patella has a marked thickening.

On its deep side, musculus ambiens makes contact with gracilis. The part of the tendon of insertion that lies in the groove on the patella is concealed by the distal end of sartorius.

Musculus ambiens adducts the thigh and extends the leg.

Gracilis. Gracilis is a slender muscle that arises from the whole medial surface of the shaft of the femur. It inserts by a tendon on the medial side of the proximal end of the medial upper tibial crest.

This muscle lies between the origin of extensor cruris and the insertion of adductor magnus. The medial surface of the major part of it is covered by musculus ambiens.

Gracilis extends the thigh.

Adductor magnus. This is a large, thick muscle. It arises from the lateral side of the pubis, ischium and the membrane between these two bones for a distance of 9.37 cm from the obturator foramen to a point 1.25 cm distant from the cartilaginous tip of the pubic bone. The fibers pass transversely to the insertion on the caudal surface of the distal half of the femur. Some of the insertion is by a special tendon on the area just above the internal condyle of the femur. To this tendon some fibers of a leg muscle (gastrocnemius) are attached.

Laterally the muscle makes contact with adductor longus and crurococcygeus.

Adductor magnus adducts and extends the thigh.

Semimembranosus. Semimembranosus is a large, flat muscle. It has two heads of origin: pubic and abdominal. The pubic head arises from the following: (1) the lateral side of the distal end of the pubic bone, including a part of the cartilaginous tip of that bone; (2) the lateral side of the adjacent distal end of the ischium; and (3) the lateral side of the caudal end of the membrane between the pubis and ischium. The abdominal head arises from the lateral surface of the abdominal wall where it is attached to the aponeurosis of the abdominal muscles for a distance of about 12.5 cm running parallel to the long axis of the body.

The fibers of both heads of origin extend to a common insertion which is on the medial side of the medial upper tibial crest. This insertion is a linear one of 5 cm, with additional fibers at the cephalic end attached to the medial side of the patella.

Laterally the pubic head makes contact with crurococcygeus and semitendinosus. Cephalically it is in contact with adductor magnus.

Semimembranosus extends the thigh and flexes the leg.

SUMMARY

1. The morphology of the muscles of the hip and thigh of the emperor penguin, *Aptenodytes fosteri*, is very similar to that given by Watson for *Eudyptes chrysocome*. However, the muscle which he described as pectineus was found to be represented in *Aptenodytes fosteri* by only a ligament.

2. As suggested by Watson the possession of an abdominal head by semimembranosus is possibly a unique feature in the anatomy of penguins.

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ZOOLOGY—*Notes on* Mecistocephalus *in the Americas, with a redescription of* Mecistocephalus guildingii *Newport* (Chilopoda: Geophilomorpha: Mecistocephalidae).

R. E. Crabill, Jr., U. S. National Museum.

(Received April 7, 1959)

Heretofore four centipede species properly referable to the genus *Mecistocephalus* have been reported from the tropics of the New World. These are: *maxillaris* (Gervais), 1837; *punctifrons* Newport, 1842; *guildingii* Newport, 1845; and *janeirensis* Verhoeff, 1938. Although I have never seen a neotropical specimen of the first, I do not doubt that it occurs in Central and South America: *maxillaris* is probably pantropical. Whether the true *punctifrons*, an Indian and southeast Asian form, is established in the Neotropics at all seems questionable, for there is reason to suspect that most or all of those neotropical specimens that have been called *punctifrons* are in fact referable to an historically obscure species, one which I believe may be peculiar to the New World Tropics. I submit that *guildingii* and *janeirensis* both refer to the same zoological entity and suggest further that it may be very widely distributed in the tropical and parts of the subtropical American continents. Indeed, it may very well prove to be as representative of the Americas as are *maxillaris* and *insularis* (Lucas), 1863, of the Old World tropics and subtropics.

This species was initially described as *guildingii* from the Antillean island of St. Vincent by George Newport in 1845 (p. 429). But inasmuch as the original characterization was quite superficial, the identity of *guildingii* has remained in obscurity until the present time.

Dr. Chamberlin we know synonymized *guildingii* under *maxillaris* (1920, p. 185), so that whenever he reported the latter in the Neotropics, as he did most recently from southern Florida (1958, p. 14), we may be sure that his specimens were either *guildingii* or *maxillaris*, and usually the former. In 1893 (p. 470) R. I. Pocock reported having seen specimens, which he called *guildingii* from the West Indies; he expressed the belief that they were not in any case conspecific with *punctifrons* and thereby disagreed with Meinert and Bollman who had thought they were. These men had seen specimens from St. Croix, Cuba, and Bermuda, and T. D. A. Cockerell had collected others on Jamica. It seems probable that all were referable to *guildingii*. Subsequently no topotypical material from St. Vincent was ever described, so that in his great monograph of 1929 (p. 156) the Count von Attems-Petzenstein was obliged to set aside *guildingii* pending clarification.

The first adequate description—it is, however, not without errors—of this centipede appeared in 1938 (p. 383) when Karl W. Verhoeff redescribed it from Rio de Janeiro, Brazil, as a new species, *janeirensis*. Topotypes of *janeirensis* from Rio de Janeiro that I have seen are, however, essentially indistinguishable from the St. Vincent topotype of *guildingii* described below. Equally similar to the St. Vincent topotype are: a series of Florida specimens recently acquired[1]; a specimen from the Panama Canal Zone; eight individuals from the island of Martinique lying in the Lesser Antilles not far to the south of St. Vincent. If it is true that (a) my topotype is really conspecific with the original cotypes, and (b) all are conspecific with the specimens cited above, then all must take the Newport name. What we understand of distribution in the genus and what we know about this particular case strongly suggest both inferences to be true.

Finally, in 1942 Wolfgang Bücherl reported the presence of *punctifrons* and *janeirensis* in Brazil, synonymizing *guildingii* under the former but admitting he had never seen a specimen of the latter. I suspect that all these specimens were actually referable to *guildingii*.

[1] I should like to express my thanks to Dr. Howard V. Weems, Jr., and to his colleagues of the State Plant Board of Florida at Gainesville for their kindness in placing these and many other specimens in my hands for study.

It seems to me that the evidence suggests: (1) that the representative and possibly endemic *Mecistocephalus* of the New World tropics is *guildingii*, and further; (2) that this species is very widely distributed from southern Florida, throughout the Caribbean and Central America, southward at least as far as southern Brazil.

The following description is based upon a single female topotype from St. Vincent. To the best of my knowledge it is the first such specimen known since the time of the original description of the Newport species in 1845. Unfortunately his original cotypical series cannot be identified in the British Museum collections today and so must be presumed to be unavailable.[2]

In the underlying description I have utilized a number of new characters and have attempted to refine some old ones. In both cases it has often seemed desirable to devise new terms to describe them, both to avoid imprecision and to propose an interlinguistic uniformity of unambiguous usage.

Imprecision of designation and the common failure of one worker to understand exactly what another meant by loose and variant usage have injected much confusion into our present, often jumbled heritage. We need to be exhaustive rather than merely minimally (and highly subjectively) analytical in describing typical material; we need to establish an unambiguous terminology and then abide by it. New terms and characters are signalized in the description and then are treated separately at the end of the paper: in addition all are illustrated in the labeled figures.

Mecistocephalus guildingii Newport, 1845

On the basis of published descriptions one could come to the conclusion either that (a) *insularis* and *guildingii* are conspecific, or (b) they are not, but are very similar to one another. On the basis of African material of *insularis* I suggest they are very similar but not conspecific. Briefly, they differ at least as follows. In *insularis* (compare with data on *guildingii* below): clypeal plagulae are as long as or somewhat longer than the anterior areolate clypeus; buccal spicula are deflected anteromedially and reach or nearly reach anterior head margin; body suffused with subsurface blackish-green pigment flecks and patches; basal plate not centrally sulcate; 1st pedal tergite not bisulcate; ultimate pedal tergite very long, sides regularly convergent, posterior margin narrowly rounded.

Topotype: female. British West Indies, St. Vincent Island. (Exact locality, collector, and date are unknown.) U.S. National Museum Myriapod Collection 2546.

INTRODUCTION. Length, 33 mm. Pedal segments, 49. Body shape: anterior five-sixths of body approximately parallel sided, final fifth gradually narrowing. Color: head, prosternum, and prehensors orange-brown; antennae, basal plate, and first pedal tergite concolorous, lightly orange-brown; tergites and sternites of anterior body third white-yellow, becoming paler posteriorly; legs essentially white to very faintly yellow-white.

ANTENNAE. Length, 3.7 mm in Hoyer's mountant. Distally slightly attenuate, each article distinctly longer than greatest width. First 4 slightly indented at outer basal corner, the remaining articles not so. First 7 clothed sparsely with very long setae, the 8th suddenly densely shortly setose as are those following. Ultimate article on outer and inner surfaces of distal half with elongate patches of short club- or spoon-shaped setae, these short and not set into depressions. CEPHALIC PLATE. Dimensions: length 1.16 mm, greatest width 0.62 mm, i.e., 1: 1.187. Shape: long and very narrow; sides straight but converging very slightly posteriorly. Frontal suture conspicuous, evenly curved posteriorly. From straight posterior margin two diverging setigerous sulci pass forward for about a third the length of the plate. Prebasal plate not detected. CLYPEUS (Fig. 1). Paraclypeal sutures distinct, complete (Note D). Each bucca (Note B) anteriorly areolate but posterior to spiculum (Note H) smooth and consolidated; buccal spicula well developed, bluntly pointed; buccal stili (Note I) long and curved, anterior incisures (Note A) distinct, deep; approximately the anterior half of each bucca glabrous, as a group the long stiff setae fall far short of the labral area and the anterior incisures of the stili. A typical clypeal area absent, in its position the areolate figures are somewhat smaller and paler. Clypeal plagulae (Note F) much shorter than the anterior areolate clypeal portion; anterior margins

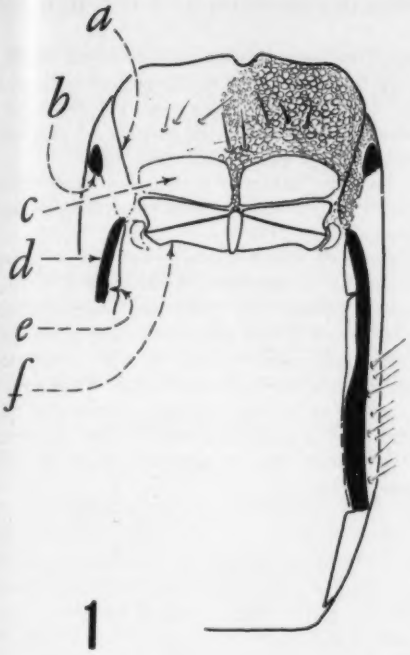
[2] I am indebted for this information to Dr. G. Owen Evans, who is in charge of the arachnid and myriapod collections at the British Museum.

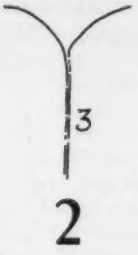
rounded, not square; separated posteriorly from labrum by a thin membranous suture and from each other by a thin areolate strip; their surface nonporous, smooth except for small rugose posteromedial corner. Setae: posterior geminate setae (Note E) essentially paramedian and just anterior to plagulae, with large alveolate sockets; midclypeal setae long and stiff, three on each side, not set into sclerotized islands. LABRUM (Fig. 1). Midpiece not projecting below sidepieces, its sides very narrowly overlapped by sidepieces medially. Anterior division of each sidepiece separated by suture from adjacent plagula; posterior divisions each with a distinct indentation laterally on posterior margin; labral posterior margin smooth, not roughened or serrulate. MANDIBLE. With 6 pectinate lamellae and one membranous hyaline projection (an incipient pectinate lamella?); the comb-teeth of each lamella from 5 (on the first) to 11 (on one of the medials); all teeth hyaline, broad, about equal in length. FIRST MAXILLAE (Fig. 6). Coxosternum with a prominent midlongitudinal suture, this margined anteriorly by a few stout setae; each anterolateral corner extended into a blunt projection, posterior to each a prominent sinuous incisure or suture (Note C); lappets absent. Medial lobes slightly shorter than telopodites; both very long, curved; telopodite lappets absent. SECOND MAXILLAE (Fig. 6). Without medial suture or sign of division; coxosternum medially and posterolaterally coarsely areolate, anterolaterally smooth, essentially consolidated; most setae set into strongly sclerotized semialveoli confluent anteriorly with a large vacant or membranous lacuna. Telepodite first article very long, curved, bicondylic basally; apical claw straight, small, very sharply pointed. PROSTERNUM (Fig. 5). Without sclerotic lines; sparsely setose; shallowly areolate; midlongitudinally very shallowly sulcate. Anteriorly shallowly diastemate, with two pale small sharp denticles. Ventral condyles displaced far to each side. TELOPODITE (Fig. 5). Flexed, well surpassing front of head. First article with two rounded prominent denticles; femoroid and tibioid each with a rounded denticle; tarsungula with a minute pointed basal denticle. Ungular blades not serrulate. Poison calyx extremely long and thin, the digitiform appendices minute, beginning at the pigmented base of the ungula proper. Poison gland extending posteriorly to level midway between denticles of first article.

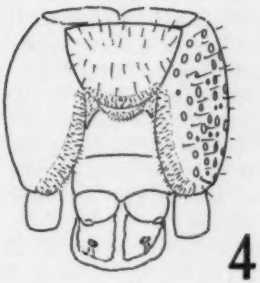
TERGITES (except ultimate pedal). Basal plate with a midlongitudinal elongate elliptical sulcus. First pedal tergite with a pair of deep paramedian sulci, these extending from posterior margin not less that three-fourths the distance to the anterior margin but not attaining it. Remaining tergites each deeply completely bisulcate. SPIRACLES. On anterior body third vertically broadly elliptical, thereafter gradually tending toward subcircular. LEGS. Dorsally very sparsely shortly setose, ventrally and laterally moderately setose, the setae long and straight. Pretarsi ventrally *evidently* not concave, at most flat basally; accessory claws acicular, not more than one-third as long as pretarsus. STERNITES (Figs. 2, 3). Rhachides (Note G) anteriorly bifurcate, subtended angles of first three or so approximately 90° when measured at base, thereafter widening slightly to subtend more than 90° (to approximately 110°); bifurcate rhachides detected on sternites 2 through approximately 25, these very weak posterior to the tenth. Sternites of about the anterior body third each with a very long metasternite extending far under the succeeding sternite.

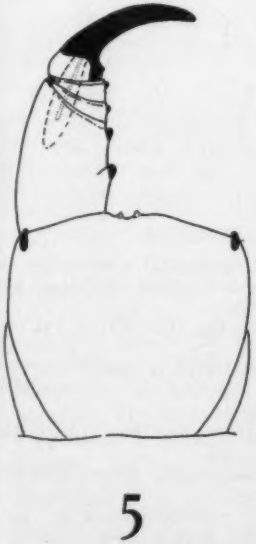
ULTIMATE PEDAL SEGMENT (Fig. 4). Pretergite separated from each of its pleurites by a pronounced suture. Tergite with perfectly straight sides and an evenly rounded posterior margin; width to greatest length = 1:1.35. Presternite distinctly divided medially. Sternite subtriangular, the sides very strongly convergent, the posterior margin rounded and very densely clothed with fine setae, with very dense underlying, apparently glandular tissue; posterior

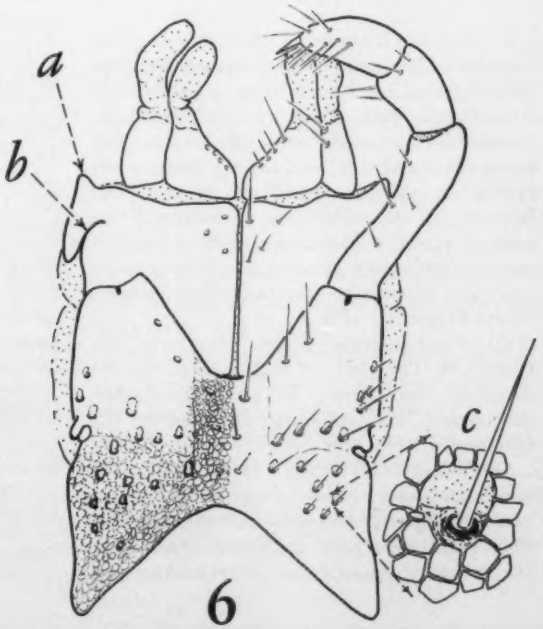
FIGS. 1–6.—*Mecistocephalus* (*M.*) *guildingii* Newport, topotype: 1, Clypeus and bucca; ventral. All setae shown; areolation of left side shown. *a*, Right paraclypeal suture. *b*, Right buccal spiculum. *c*, Right plagula. *d*, Anterior end of right buccal stilus. *e*, Anterior incisure of stilus. *f*, Indentation on right labral sidepiece. 2, Rhachis of third pedal sternite. 3, Rhachis of eighth pedal sternite. 4, Ultimate pedal and postpedal segments; ventral. All setae of sternite and left coxopleuron shown; those of postpedal segments deleted. 5, Prosternum and right prehensor; ventral. All setae deleted. Dashed outline of poison calyx shown inside that of poison gland. 6, First and second maxillae; ventral. All setae of left side shown; setal alveoli and lacunae of right side shown. Areolation of right side shown, those of left deleted. *a*, Anterolateral projection of first maxillary coxosternum. *b*, Right lateral incisure of first maxillary coxosternum. *c*, Setae with alveoli and lacuna *in situ* and enlarged.











FIGS. 1–6.—(See opposite page for legend).

rounded margin followed by a cushionlike mound, this also densely finely setigerous. Each coxopleuron swollen, not extending anteriorly beyond rear margin of penultimate pedal segment; pores large and slightly smaller, distributed uniformly but absent ventromedially, ventroposteriorly, dorsomedially, and dorsoposteriorly; ventromedial edge raised and swollen, densely finely setose and with dense underlying glandular tissue. Ultimate legs very thin and long, with long stiff setae; pretarsus represented by a microscopic terminal bristle. POSTPEDAL SEGMENTS (Fig. 4). Gonopods well separated; basal article broad and flat; second article minute, nipplelike, only indistinctly separated from the basal. Terminal pores conspicuous.

The other specimens that I have examined all agree very closely with one another and with the St. Vincent topotype. In the males the ultimate sternite seems somewhat broader and shorter, the coxopleura shorter than the corresponding parts of the females.

Lengths (in mm): 5 males: 19, 21, 29, 30, 33; 11 females: 27, 28, 28, 30, 30, 30, 32, 33, 33, 33, 36. FLORIDA: Miami, South Miami, Rockdale, Key West. PANAMA CANAL ZONE: Frijoles. MARTINIQUE: Rivière Pilote. BRAZIL: Rio de Janeiro.

NOTES

A. Anterior Incisure (of the Stilus); New Character. The anterior cleft or break on the medial side of the buccal stilus, q.v. (Fig. 1e.)

B. Bucca; New Term (pl. = buccae, L. "cheek"). The so-called cephalic pleuron; that portion of the ventral head capsule bounded anteriorly by the paraclypeal sutures, q.v., and laterally by the folded lateral margin of the cephalic plate; a neutral descriptive term proposed to replace the morphologically implicative "pleuron" of authors. (See also stilus, spiculus, anterior incisure.) (Fig. 1.)

C. Lateral Incisure (of First Maxillae); New Character. The cleft on each side of the 1st maxillary coxosternum. Its presence, absence, development, and position are all significant systematically. (Fig. 6b.)

D. Paraclypeal Sutures; New Character. The sutures or grooves in most Geophilomorpha that pass from the antennal sockets shortly laterally, then ventroposteriorly usually to terminate in the vicinity of the outer end of each labral sidepiece. When present they may be taken to define the lateral limits of the clypeus and the anterior limits of each bucca, q.v. The degree of development, the course, the termination of these sutures all have significance. (Fig. 1a.)

E. Posterior Geminate Setae; New Term. The persistent pair of setae located posteriorly on the clypeal midline. (Fig. 1.)

F. Plagula (of the Clypeus); New Term (pl. = plagulae; L. "a small flat surface or area"). The so-called clypeal or preclypeal consolidated area(s), or in Mecistocephalidae the posterior clypeus; widespread in the order, though in many families much smaller in size. When present, so far as is known always paired and bilateral, each occupying a position just anterior to the labrum on the posterior part of the clypeus. (Fig. 1c.)

G. Rhachis (or Rachis); New Term (pl. = rhachides, rachides, G. "a ridge, axis, backbone"). In Mecistocephalidae the elongate, midlongitudinal sternital thickenings, especially characteristic of the more anterior sternites. The rhachis is apparently in reality a very narrowly inverted sternital fold whose surfaces, in any case, serve as areas of muscular attachment. Anteriorly the rhachis is bifurcate or not; if bifurcate, the size of the angle *subtended by the bases* of the anterior arms, within limits, has systematic significance. (Figs. 2, 3.)

H. Spiculum (of the Bucca); New Term (pl. = spicula, L. "a small spike or sharp point"). In Mecistocephalidae, the pigmented spikelike point on the anterior part of the bucca, q.v. (Fig. 1b.)

I. Stilus (of the Bucca); New Term (pl. = stili, L. "a pointed writing instrument"). The heavily sclerotized, elongate, usually blunt and thickened inner edge of the bucca; at midlength giving attachment to the maxillae. (Fig. 1d.)

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ZOOLOGY—*A new species of* Haloptilus *(Copepoda: Calanoida) from equatorial and subtropical waters of the east-central Pacific Ocean*[1]

GEORGE D. GRICE,[2] Woods Hole Oceanographic Institution, Woods Hole, Mass. (Communicated by Paul L. Illg.)

(Received April 3, 1959)

The new species of *Haloptilus* described below was found while examining a series of plankton samples which had been collected by the U. S. Fish and Wildlife Service as part of their oceanographical and marine biological studies in the Pacific Ocean.

Haloptilus austini, n. sp.

Figs. 1–18

Localities and materials.—Latitude 28°00′N., longitude 159°03′W. (U. S. Fish and Wildlife Service *Hugh M. Smith* Cruise 27, station 67, February 19, 1955, 100–0 m depth of tow, 1 female); latitude 00°11′S., longitude 119°58′W. (*Hugh M. Smith* Cruise 31, station 94-2, November 7, 1955, 146–72 m depth of tow, 2 females). Physical oceanographic and other data for Cruise 27 are summarized by McGary and Stroup (1958) and that for Cruise 31 by King, Austin, and Doty (1957).

Types.—All three specimens have been deposited in the U. S. National Museum. A female from Cruise 31 was selected as the holotype (U.S.N.M. no. 102742). Paratype numbers are as follows: U.S.N.M. no. 102744 (1 female, Cruise 31) and U.S.N.M. no. 102743 (1 female, Cruise 27).

Description.—Female (Figs. 1–18). The cephalothorax is much longer than the abdomen, the ratio of these two body parts being approximately 8 to 1 (Fig. 1). The head is rounded and considerably produced anteriorly (Figs. 1 and 2). A convex protrusion is present on each side at a point adjacent to the origin of the second antennae. The rostral filaments (Figs. 2 and 3) arise from two small elevations which are situated a short distance in front of the origin of the first antennae.

The abdomen (Figs. 4, 5, and 6) consists of 4 segments. The genital segment is longer than the combined lengths of the succeeding 3 segments.

The first antennae of all three specimens are broken off at segment 22. When held against the body, segment 20 reaches to approximately the end of the caudal furcae. The endopod of the second antennae (Fig. 7) is a little less than twice the length of the exopod. The exopod consists of 7 segments. Segment 1 has 2 setae. Segments 2 through 6 are furnished with a single seta. There are 4 setae on segment 7. The first segment of the endopod has 2 setae situated just beyond the mid-point of this segment. The external lobe of the second endopodal segment has 6 large and 1 minute seta. The internal lobe has 8 setae, 4 of which are notably small.

The exopod of the mandible (Fig. 8) is a little more than one-half the length of the endopod. The former apparently consists of 5 segments, the first 4 of which are furnished with a seta. The terminal segment has 2 setae. Segment 1 of the endopod has 2 setae distally, and segment 2 is provided with 8 terminal setae. The gnathal lobe of the mandible is shown in Fig. 9.

The first maxilla is shown in Fig. 10. The exopod is elongate and furnished with 11 setae. Four of the setae on the distal margin are quite small and slender (Fig. 11). The endopod carries 5 setae, and the second basal segment bears 4 setae. Inner lobes 1, 2 and 3 bear 7, 2 and 4 setae, respectively. The external lobe has 6 large and 3 small setae.

The second maxilla (Fig. 12) has 6 lobes. Lobes 1 through 4 and lobe 6 have 3 setae. Lobe 5 has 2 setae. The distal part of this appendage is furnished with 7 setae.

The maxilliped (Fig. 13) consists of 2 basal and 5 endopodal segments. The first basal segment has 2 setae near the proximal end, 3 setae near the center, and 3 setae near the distal end. The second basal segment is furnished with 2 setae near the center and 2 setae on the distolateral corner. Endopodal segments 1 and 2 have 4 setae and segments 3 and 4 have 3 setae. The fifth segment is furnished with 1 seta and 3 bristles.

The first to fourth pairs of swimming feet are

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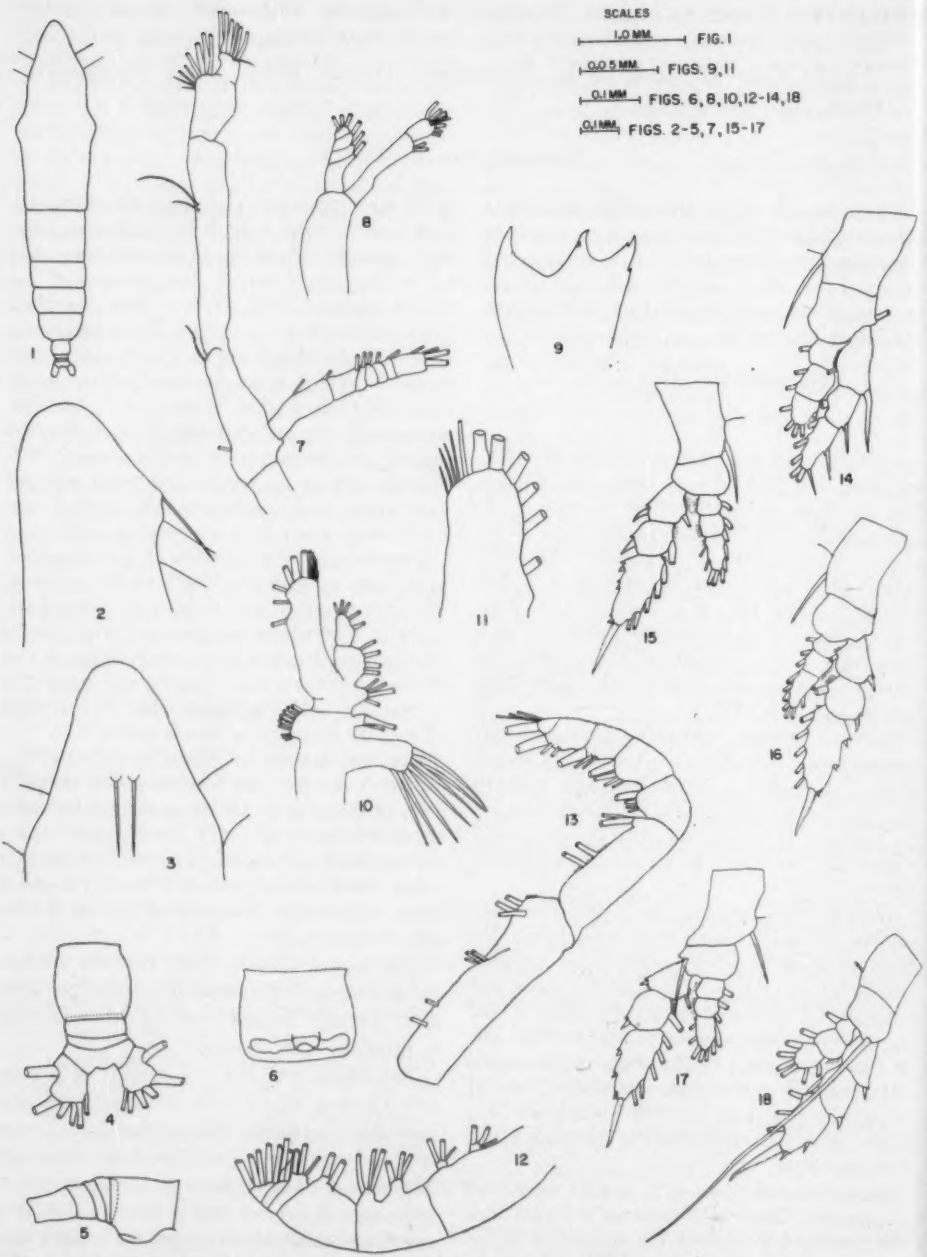
[2] Fellow of the John Simon Guggenheim Memorial Foundation, 1958–1959.



FIGS. 1–18.—*Haloptilus austini*, n. sp., female: 1, Dorsal; 2, forehead, lateral view; 3, forehead, ventral view; 4, abdomen, dorsal view; 5, abdomen, lateral view; 6, genital segment, ventral view; 7, second antenna; 8, mandibular palpus; 9, gnathal lobe of mandible; 10, first maxilla; 11, terminal part of exopod of first maxilla; 12, second maxilla; 13, maxilliped; 14, first foot; 15, second foot; 16, third foot; 17, fourth foot; 18, fifth foot. Fig. 11 drawn from paratype. All other figures drawn from holotype.

shown in Figs. 14 through 17. The first pair of feet is smaller than the succeeding 3 pairs. There is 1 seta on the internal margin of basipodal segment 1 and 1 seta on the external margin of basipodal segment 2. Both exopod and endopod consist of 3 segments. Segments 1 and 2 of the exopod have 1 long external spine and 1 internal seta. Segment 3 has 2 external spines and 4 internal and 1 terminal seta. Endopodal segment 1 has 1, segment 2 has 2, and segment 3 has 5 setae.

The second, third, and fourth pairs of feet are similar. Basipodal segment 1 has an internal seta. Basipodal segment 2 of the second and third feet is naked. This segment of the fourth feet is furnished with an external seta. Segments 1 and 2 of the exopod have a small external spine and a single internal seta. The third exopodal segment has a terminal, finely serrate spine. There are 3 small external spines and 5 internal setae on this segment. In the second and fourth pairs of feet, endopodal segment 1 has 1 seta, segment 2 has 2 setae, and segment 3 has 7 setae. In the third pair of feet the numbers of setae on these respective segments of the endopod are 1, 2, and 8.

The fifth pair (Fig. 18) of feet is smaller than the preceding 3 pairs. Basipodal segment 1 has 1 internal seta. Basipodal segment 2 is furnished with 1 seta which exceeds the tip of the terminal exopodal spine. Exopodal segment 1 has 1 external spine, segment 2 has 1 external and 1 internal spine, and segment 3 has 2 external and 1 terminal spine. Segment 3 is also furnished with 3 internal setae. Endopodal segments 1, 2, and 3 are provided with 1, 1, and 6 setae, respectively.

Total length of the three specimens is as follows: 3.33 mm (holotype), 3.16 mm (paratype, Cruise 31) and 3.06 mm (paratype, Cruise 27).

No male has been found.

Remarks.—This species resembles *H. chierchiae* (Giesbrecht) but may readily be distinguished from it by the shape of the head and the structure of the first maxillae and fifth pair of feet. The head of *H. austini* is considerably more produced anteriorly. In regard to the first maxilla of *H. austini*, the second basal segment has 4 setae, the exopod has 11 setae, and the endopod has 5 setae. The corresponding parts of the first maxilla of *H. chierchiae*, as figured by Giesbrecht (1892) and Sars (1924), have 5 setae, 8 setae, and 7 setae. The seta on the second basal segment of the fifth pair of legs of *H. austini* exceeds the tip of the terminal exopodal spine. In *H. chierchiae* this seta, as figured by Sars (1924), does not reach the distal end of the second exopodal segment. This new copepod is named in honor of Thomas S. Austin, oceanographer, Honolulu Biological Laboratory, U. S. Fish and Wildlife Service.

Acknowledgments.—The Honolulu Biological Laboratory, U. S. Fish and Wildlife Service, provided laboratory space during the course of the investigation. Dr. W. Vervoort has kindly read the manuscript.

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They will tell you to try to prove you are right; I tell you to try to prove you are wrong.—LOUIS PASTEUR.

James Herbert Hibben

JAMES H. HIBBEN, for 20 years chief of the chemical division of the U. S. Tariff Commission and one of the foremost chemical consultants in the United States, died suddenly on June 15, 1959, at George Washington University Hospital after a fall at his home.

Dr. Hibben, the son of Thomas E. and Jeanie Ketcham Hibben, was born in Indianapolis, Ind., on May 14, 1897. He attended public schools in Indianapolis; was a graduate of the University of Illinois, receiving his B. S. in 1920 and his M. S. in 1922; and of the University of Paris (1924) with the degree of D. Sc. He has been a fellow of the International Education Board at Paris (1924), a National Research Fellow at Princeton University (1925–27), consultant to the Bureau of Standards and to various chemical industries, and a member of the research staff of the Geophysical Laboratory of the Carnegie Institution of Washington (1928–1939). During World War I Dr. Hibben enlisted in the Army as a private and served with the A.E.F., being discharged in 1919 with the rank of sergeant. Decorations and awards: St. Mihiel and Marne Defense Sector.

Dr. Hibben was a member of the Washington Academy of Science (vice pres.); New York Academy of Sciences; the Cosmos Club; American Chemical Society; the Chemical Society of Washington (treas., sec., pres.; Hillebrand Prize award); Sigma Xi and Sigma Chi; and a former fellow of the American Institute of Chemists.

He was the author of several books and many papers. One of his best-known works was the book entitled *The Raman effect and its chemical application* (1939). This was one of the first definitive works on this subject. It brought together all the then known information on a new type of secondary radiation information by which the behavior of atoms within the molecules and the molecules themselves may be determined independently of their state of aggregation. Many applications of this effect have been made, both to physics and chemistry, and Hibben's "Raman Spectra" is still used as the starting point for much of this work.

At the Tariff Commission Dr. Hibben carried out many complex and important responsibilities which, by law or Executive order, the Commission is charged with making. He provided basic and authoritative information to the Commission, to top ranking officials of Government agencies, executives of industry, and, when necessary, to members and committees of Congress and the Office of the President on matters relating to United States tariffs and foreign trade pertaining to chemicals and chemical products. During World War II he was chairman or member of many intra agency committees and commissions. He was directly responsible for the organization and publication of the Tariff Commission's annual report on *Synthetic organic chemicals. U. S. production and sales.*

Dr. Hibben is survived by his wife, the former Louise Douglas of Indianapolis; a daughter, Mrs. Phyllisann Courtis; a granddaughter, Lisa; and two sisters, in Indianapolis.

FISHER AWARD

Dr. James I. Hoffman, chief, metallurgy division, National Bureau of Standards, is the recipient of the 1959 Fisher Award in Analytical Chemistry. This award is the highest recognition for work in analytical chemistry in the United States and Canada. It consists of $1,000 and an etching. Presentation of the award was on April 6, 1959, at the meeting of the Society in Boston.